USAF/NATO CONFERENCE

Best available copy

MAINTENANCE OF AIRBASE OPERATIONS IN A CHEMICAL WARFARE ENVIRONMENT

WILLIAMSBURG, VIRGINIA
U. S. A.

Chemical-Biological
Information Analysis
Center

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Proceedings of the

USAF/NATO Conference

on

Maintenance of Air Base

Operations in a Chemical

Warfare Environment

Sponsored by:

U.S. Air Force Systems Command

Aeronautical Systems Division

Williamsburg, Virginia

August - September 1987

DISCLAIMER

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Table of Contents con't

* Paper presented at the Conference, Abstract only included in the Proceedings

** Paper not presented at the Conference, not included in the Proceedings

*** Paper presented at the Conference, not included in the Proceedings

PREFACE

The United States Air Force Systems Command Aeronautical Systems Division Conference on "Maintenance of Air Base Operations in a Chemical Warfare Environment" for the North Atlantic Treaty Organization was held 31 August - 4 September, 1987 at Williamsburg, Virginia -- Hilton National Conference Center and Fort Eustis.

The purposes of the Conference were:

- Foster cooperation among NATO community members on chemical survivability and maintenance of essential air base operations while under chemical attack;
- Assess the status of research and development in the protection of air and ground crews in a chemical environment; and
- Exchange information among NATO community members on air base operations and air and ground crew survivability in a chemical environment.

Keywords: Individual Protection, Collective Protection, Protective Equipment, Chemical Agent Detectors,

The Conference served as an informal forum for scientific and technical exchange and stimulation among the NATO community elements. The conference format involved four days of presentation and discussions among the invited participants.

Included herein are the Proceedings Papers, a list of registrants and the Conference Agenda.

Detection, Toxic Agent Alarms, Monitors, Decontamination. (AW)

An Overview of the U.S. Air Force Chemical Warfare Defense Program

Lt Col Lawrence Hagenauer
Chemical Warfare Defense PEM
U.S. Air Force
The Pentagon
SAF/AQPN
Washington, D.C. 20330-5040

The US Air Force Chemical Warfare Defense Program is based on the goals stated by Secretary of Defense Casper D. Weinberger in his annual report to the Congress in support of the FY 1988 Defense Budget.

"The objective of the Department of Defense Chemical Warfare and Biological Defense Program is to prevent the use of chemical and biological agents against members of the U.S. Armed Forces... We must equip our forces with the best defensive chemical warfare equipment available to ensure their survival and effective operation."

Reflecting this general statement of objectives, the U.S. Air Force goal can be stated as follows:

Deter the threat of a chemical weapon attack through the combination of a credible retaliatory capability and an operationally effective defense; if subjected to a chemical weapon attack provide a survival capability and also maintain aircraft operations with a minimum of degradation.

The Air Force program can be viewed best by addressing three separate time periods of capability; first, those systems which provide today's capability, second, those systems currently in engineering development to be fielded in the next several years, and third, a development strategy for the future

<u>Current Capability:</u>

"Individual Protection"

- U.S. Army battle dress overgarment
- M 17 Series mask with rear term replacement by the MCV-21P mask
- Chemical protective overboot
- U.K. aircrew chemical protective undergarment
- Aircrew mask derived from the aircraft smoke mask

These systems provide a basic survival capability with several operational limitations. The battle dress overgarment is not reusable, the chemical protective overboot is difficult to clean and bulky to wear, and the total aircrew protective is uncomfortable and has several areas of vision restrictions. Immediate improvements in this area will result from fielding the MCV-21P mask and fielding of the U.S. Army green vinyl overshoe to replace the chemical protective overboot.

"Collective Protection"

- Construction programs to include chemical protection added to squadron operations buildings and hardened avionics repair facilities.

- Installation of the survivable collective protection system (SCPS)

The combination of protected construction facilities as well as SCPS for rest and relief has provided us with a true sustained operational capability.

"Detection and Warning"

- M 256 Detection Kit

- M-8 / M-9 Detection Paper

- M8A1 Automatic Detector and Alarm

- Automatic Liquid Agent Detector (ALAD)

- Chemical Agent Monitor (CAM)

The M 256 Kits and M-8 / M-9 Detection paper have been fielded for some time, however the M8A1, and ALAD and the CAM are providing the first benefits of recent efforts to apply improved technology to the needs of detection and warning.

"Decontamination"

- Light Weight Decontamination System (LDS)

- M 258 Skin Decontamination Kit

- M 258A1 / M 280 Skin and Equipment

Decontamination systems currently in use do not reflect a great change from the last several years. The LDS is a hot water contamination removal system and the M 258 kit is being phased out in favor of the M 258A1 / M 280 system which contains disposable towlettes saturated with decontaminating agent.

Development:

Items in current development will be entering production in the next several years. These systems will fill voids in our current systems to strengthen our sustained capability and lessor the operational impact of defensive equipment or sortie generation.

"Individual Protection"

- Aircrew Eye Respiratory Protection, (AERP) Program

- Body Cooling for Ground Crews

The AERP program is intended to provide a better aircrew mask for all Air Force aircraft and crews to increase protection and decrease the burden or aircrews. We have surveyed many current systems to determine what is available for adoption without requiring further development. Equipment selections w[illegible]e made and system integration begun within the next several months. We have also begun a new approach to ground crew body cooling employing a "cooling island" to which personnel can attach during rest cycles. A demonstration of two systems, one based on liquid cooling and the other on cooled air, is planned for next summer.

"Collective Protection (Transportable Collective Protections)"

- Rigid Wall Shelter hardening programs

- Tent liner kits and contamination control areas (CCA)

Collective protection liners are being added to tactical shelters that are part of our current bare base development kits. In addition the Air Force is participating in the U.S. Army development of the TEMPER tent liner as well as developing a transportable CCA for attachment to these tents. The CCA unit being developed will also be usable as a stand alone shelter for expedient use.

"Detection and Warning"

- Command and Control

- Paint Detector Requirements

- Remote Detector

- Complete System Integration

The Air Force Fixed Site Detection and Warning System will look at the total requirements of a warning system. It will include not only the need for early warning but requirements for dewarning to expedite lowering of the MOPP level thus decreasing the burden of wearing full protective equipment.

"Decontamination"

Future Air Force efforts will concentrate on application of Freon decontamination for avionics equipment. We plan to install large size units into avionics repair facilities for large electronic pods and also participate in a smaller unit development with the US Army. This smaller unit will be used to decontaminate avionics units (commonly known as "black boxes") prior to disassembly and repair.

Air Force future strategy will concentrate on detection and warning systems and concepts. We will continue to improve individual protective equipment, complete the aircrew (AERP) system production and install avionics decontaminating equipment. However, the greatest payoffs can be made through improvements in detection and warning. If areas of contamination can be positively identified, the effort required for sustained operations can be greatly decreased through contamination avoidance and effective decontamination.

#1

US AIR FORCE

CHEMICAL WARFARE DEFENSE PROGRAM

LT COL LAWRENCE HAGENAUER
AERONAUTICAL & TEST DIVISION
OFFICE OF THE SECRETARY OF
THE AIR FORCE (ACQUISITION)

#2

ANNUAL REPORT TO THE CONGRESS
CASPER D. WEINBERGER
SECRETARY OF DEFENSE
FISCAL YEAR 1988

" THE OBJECTIVE OF THE DEPARTMENT OF DEFENSE CHEMICAL WARFARE AND BIOLOGICAL DEFENSE PROGRAM IS TO PREVENT THE USE OF CHEMICAL AND BIOLOGICAL AGENTS AGAINST MEMBERS OF THE U.S. ARMED FORCES ... WE MUST EQUIP OUR FORCES WITH THE BEST DEFENSIVE CHEMICAL WARFARE EQUIPMENT AVAILABLE TO ENSURE THEIR SURVIVAL AND EFFECTIVE OPERATION ... "

#3

US AIR FORCE GOAL FOR CHEMICAL DEFENSE

DETER THE THREAT OF A CHEMICAL WEAPON ATTACK
- A CREDIBLE RETALIATORY CAPABILITY
- AN OPERATIONALLY EFFECTIVE DEFENSE CAPABILITY

IF SUBJECTED TO A CHEMICAL WEAPON ATTACK
- PROVIDE A SURVIVAL CAPABILITY
- MAINTAIN AIRCRAFT OPERATIONS WITH MINIMUM DEGRADATION

#4

OVERVIEW

CURRENT SYSTEMS - IN THE INVENTORY/NEW DELIVERIES

NEW DEVELOPMENTS - THE NEXT SEVERAL YEARS

DEVELOPMENT STRATEGY FOR THE FUTURE

#5

CURRENT SYSTEMS
OUR CAPABILITY TODAY

EQUIPMENT IN THE INVENTORY

PRODUCT IMPROVEMENTS

EQUIPMENT IN INITIAL DELIVERY

#6

INDIVIDUAL PROTECTION

BATTLE DRESS OVERGARMENT

M17 SERIES MASK

CHEMICAL PROTECTIVE OVERBOOT

BUTYL RUBBER GLOVES

#7

INDIVIDUAL PROTECTION CURRENT IMPROVEMENTS

MCU-2/P MASK
- IMPROVED PROTECTION THROUGH BETTER FIT
- BETTER VISIBILITY
- NATO STANDARD QUICK CHANGE FILTER CANISTER

CHEMICAL PROTECTIVE FOOTWARE
- GREEN VINYL OVERSHOE
- CURRENT INVENTORY US ARMY FOUL WEATHER BOOT

#8

COLLECTIVE PROTECTION

CONSTRUCTION PROGRAMS
- SQUADRON OPERATIONS BUILDINGS
- AVIONICS REPAIR FACILITIES IN EUROPE

SURVIVABLE COLLECTIVE PROTECTION SYSTEM
- BEING INSTALLED IN EUROPE NOW

#9

DETECTION AND WARNING

M256

M-8/M-9 DETECTION PAPER

M8A1 AUTOMATIC DETECTOR AND ALARM

AUTOMATIC LIQUID AGENT DETECTOR

CHEMICAL AGENT MONITOR

#10

DECONTAMINATION

LIGHT WEIGHT DECONTAMINATION SYSTEM
- HOT WATER CONTAMINATION REMOVAL

M258 SKIN DECONTAMINATION KIT
- CURRENTLY BEING REPLACED

M258A1/M280 SKIN AND EQUIPMENT DECONTAMINATION KITS
- INDIVIDUAL TOWELETTE SYSTEM

#11

NEW DEVELOPMENTS

THE NEXT SEVERAL YEARS

#12

INDIVIDUAL PROTECTION

IMPROVED AIRCREW MASK
- CURRENT MASK HAS MANY DRAWBACKS
- TOP US AIR FORCE C/W DEFENSE PROGRAM

BODY COOLING
- FOR FIXED SITE OPERATIONS
- MULTI-MAN INTERMITTENT CONCEPT

IMPROVED INDIVIDUAL PROTECTIVE SUIT
- DECONTAMINABLE TO REDUCE SUPPLY PROBLEM ON A FIXED SITE WITH LONG TERM CONTAMINATION

#13

COLLECTIVE PROTECTION

TRANSPORTABLE COLLECTIVE PROTECTION

RIGID WALL SHELTERS
- US AIR FORCE BARE BASE DEPLOYMENT KITS

TENTS
- LINER KITS IN DEVELOPMENT WITH THE ARMY
- ENTRY/EXIT SYSTEMS BEING DEVELOPED BY THE AIR FORCE

#14

DETECTION AND WARNING

FIXED SITE DETECTION AND WARNING SYSTEM

- COMMAND AND CONTROL
- POINT DETECTOR REQUIREMENTS
- REMOTE DETECTORS
- INTEGRATION OF COMPLETE SYSTEM

#15

DECONTAMINATION

NON-AQUEOUS SYSTEMS, FREON BASED

- LARGE SIZE, TO BE CONSTRUCTED AS PART OF THE FACILITY
- GLOVEBOX SIZE, FIXED SITE APPLICATIONS

#16

FUTURE STRATEGY

CONTINUE EQUIPAGE WITH CURRENT SYSTEMS

CONTINUE IMPROVEMENT OF FIELDED EQUIPMENT FOR PROTECTION AND DECONTAMINATION

COMPLETE CURRENT EQUIPMENT DEVELOPMENT PROGRAMS
- AIRCREW PROTECTION
- TRANSPORTABLE COLLECTIVE PROTECTION
- NON-AQUEOUS DECONTAMINATION

EMPHASIZE DETECTION AND WARNING SYSTEMS INTEGRATION
- AREA WITH GREATEST POTENTIAL OPERATIONAL PAYOFF
- CONCENTRATE ON COMMAND AND CONTROL

U.S. ARMY CW/CBD OVERVIEW

DR. B. RICHARDSON

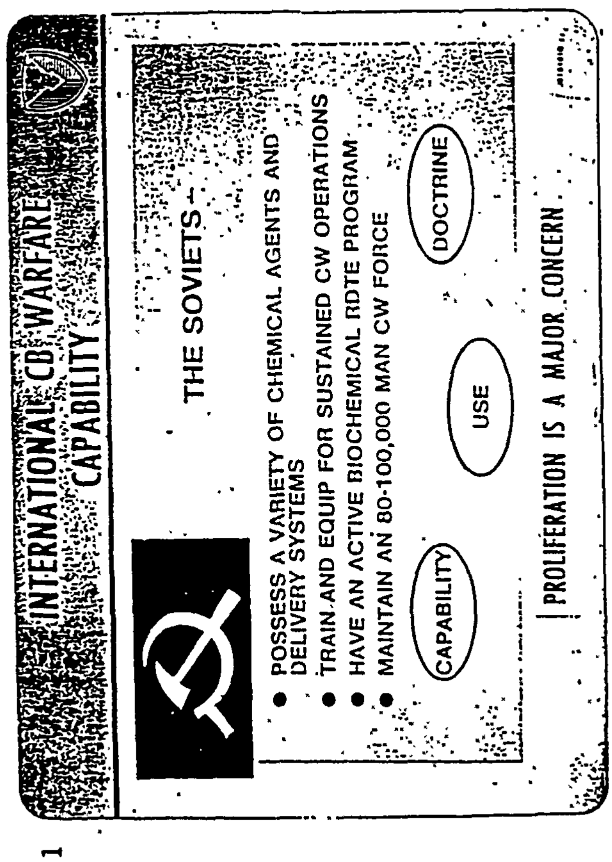
PROGRAM EXECUTIVE OFFICER
CHEMICAL/NUCLEAR

PROGRAM EXECUTIVE OFFICER
CHEMICAL/NUCLEAR

U.S. Army CW/CBD Overview

Dr. Billy Richardson
Program Executive Officer
Chemical/Nuclear

#1



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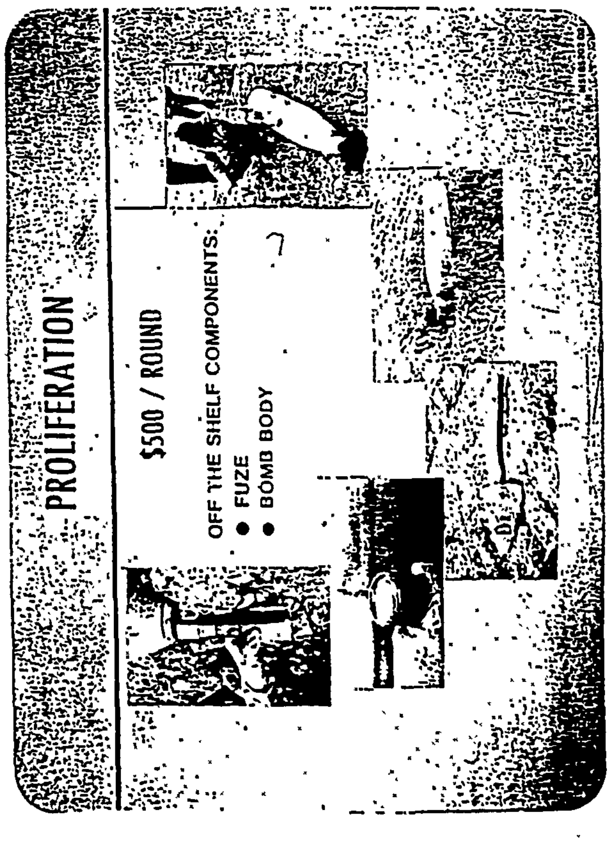

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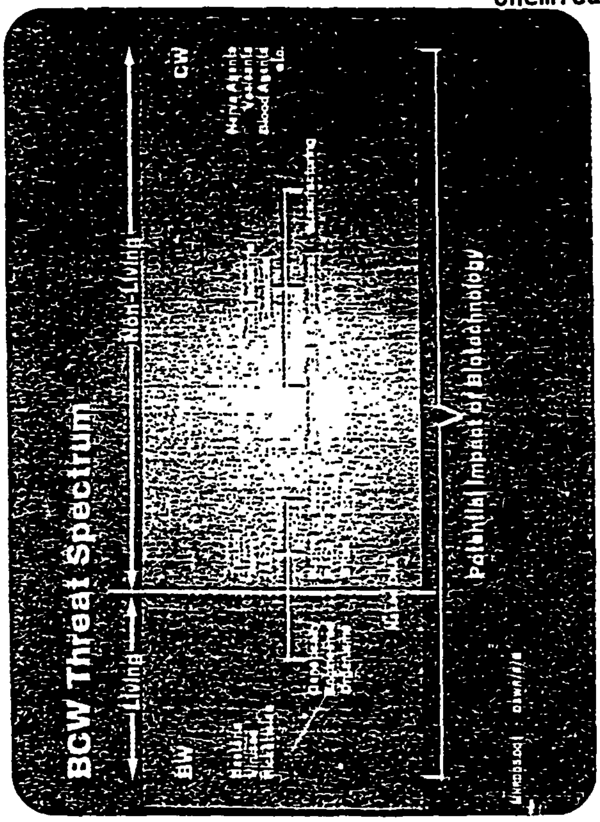

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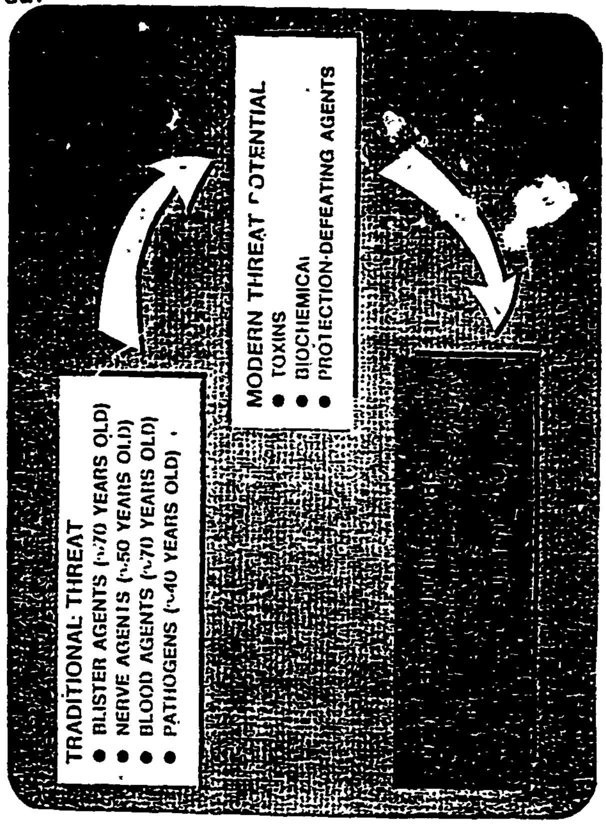

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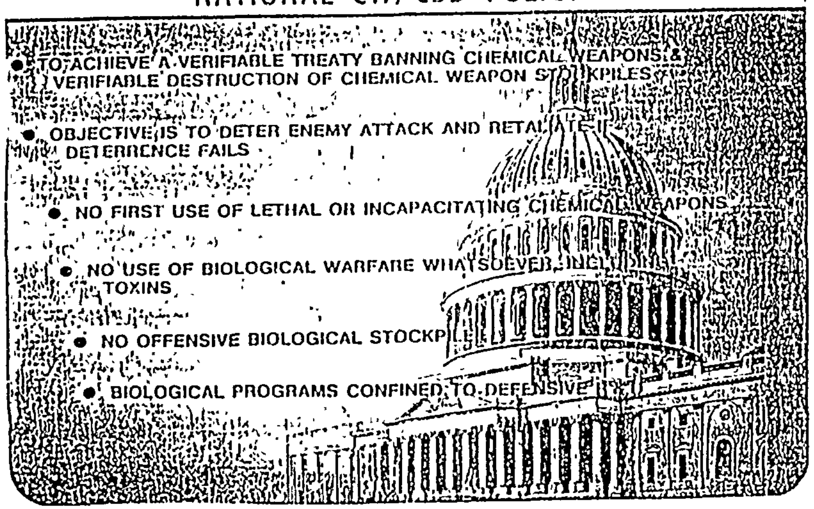
CURRENT
NATIONAL CW/CBD POLICY



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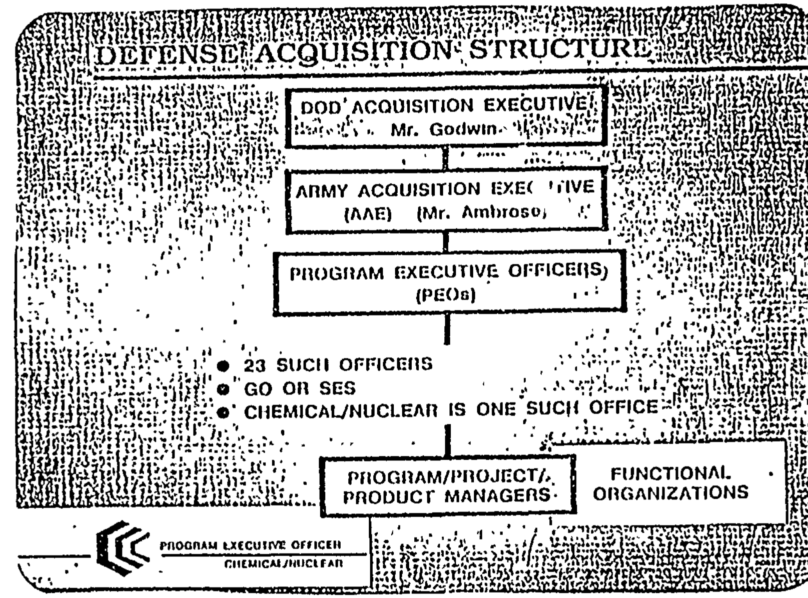

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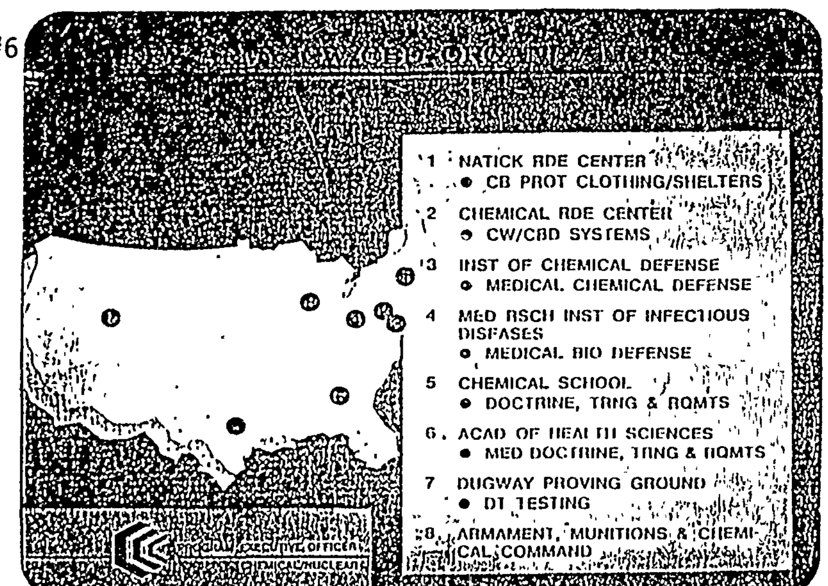

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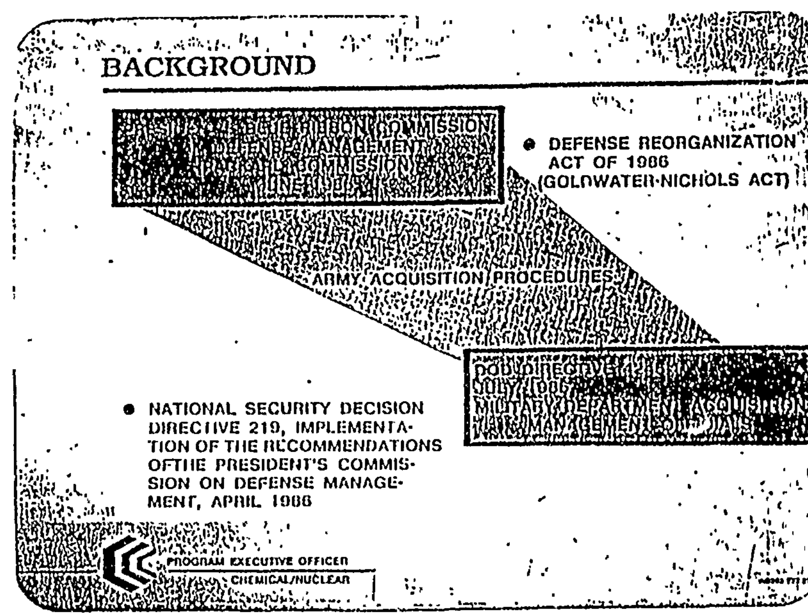


#9

PROGRAM EXECUTIVE OFFICER CHEMICAL/NUCLEAR - SCOPE

PMs
- BINARY (COL(P) Bob Orton)
- SMOKE (COL Mod Durol)
- NBC DEFENSE (COL Jan Van Prooyen)

- CRDEC PROGRAMS
- RADIAC PROGRAMS (CECOM)

MAYBE –
- CHEMICAL PROTECTIVE GARMENTS (NRDEC)
- CHEMICAL ASPECTS OF SHELTERS (NRDEC)
- TECHNOLOGY BASE (THIS PEO ONLY)
- MEDICAL CHEMICAL-BIOLOGICAL DEFENSE (MRDC)
- PM NUCLEAR MUNITIONS

PROGRAM EXECUTIVE OFFICER CHEMICAL/NUCLEAR

#11

- IMPROVE UNITY OF APPROACH AND POSITION WITHIN CHEMICAL COMMUNITY
- INCREASE SUPPORT FOR PROGRAM LEVELS THAT ARE REALISTIC IN VIEW OF THE THREAT AND VULNERABILITIES
- ACHIEVE PACKARD COMMISSION INTENT: IMPROVE THE PROCESS
- PROVIDE A YIELD ON THE INVESTMENT THE PEO SYSTEM REPRESENTS

PROGRAM EXECUTIVE OFFICER CHEMICAL/NUCLEAR

#10

PEO FUNCTIONS

- FINANCIAL REPROGRAMMING AUTHORITY
- CONGRESSIONAL AND DA INTERFACE
- GENERAL PROGRAM OVERSIGHT
- IN-PROCESS REVIEW AUTHORITY
- OVERSEE/SUPPORT PMs

GENERAL: SERVE AS A SINGLE NAME AND PHONE NUMBER FOR ANY QUESTION ON CHEMICAL MATTERS, SOME NUCLEAR MATTERS

PROGRAM EXECUTIVE OFFICER CHEMICAL/NUCLEAR

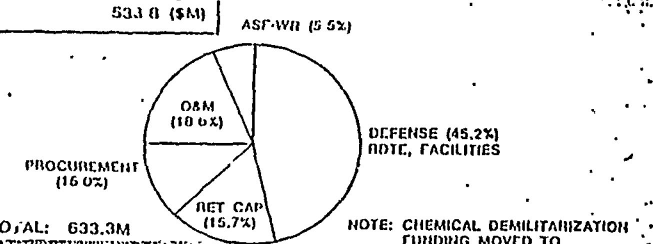
#12

CHEMICAL WARFARE/NUCLEAR, BIOLOGICAL AND CHEMICAL DEFENSE PROGRAM – FY 88

FY88 ($M)

DEFENSIVE (84%)	
RDTE (NBC EQUIP)	141.3
RDTE (MEDICAL)	138.9
ASF WAR RESERVE	35.0
O&M	118.0
PROCUREMENT	95.3
FACILITIES	5.3
	533.8 ($M)

RETALIATORY CAPABILITY (16%)	
RDTE (TECH BASE)	9.5
RDTE (BINARY)	30.7
PROCUREMENT (BINARY)	59.3
	99.5 ($M)



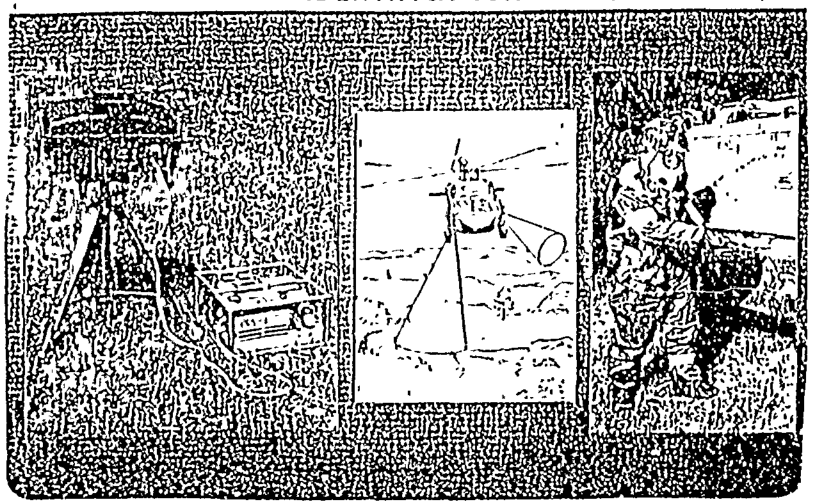
TOTAL: 633.3M

NOTE: CHEMICAL DEMILITARIZATION FUNDING MOVED TO DOD ACCOUNT

PROGRAM EXECUTIVE OFFICER CHEMICAL/NUCLEAR

#13

RECONNAISSANCE, DETECTION AND IDENTIFICATION



#14

DEVELOPMENT: CHEMICAL AGENT MONITOR

TECHNOLOGY DEVELOPED AT CRDEC BY JOINT US-UK TEAM

HARDWARE DEVELOPED AT UK CDE

JOINT TEST PROGRAM

TC - LP

UK AND US PRODUCTION

FIRST REAL TIME, HAND HELD CHEMICAL DETECTOR

#15

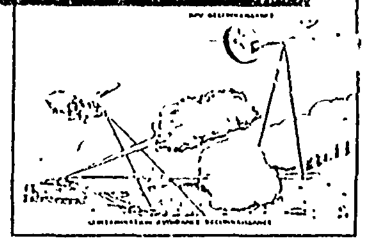
REMOTE AGENT DETECTION

DEMONSTRATED:

- DETECTION TO 10 Km
- SENSITIVITY TO 0.08 Mg/M^3
- VAPOR MAPPING TO 5 Km
- MULTIPLE AGENT DETECTION
- INTERFERENTS (SMOKES, DUST, RAIN) REJECTION
- DETECTION ON SURFACES

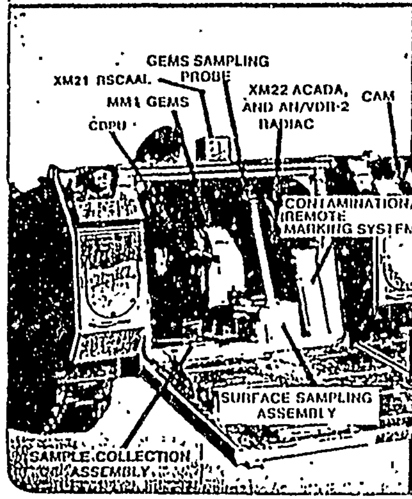
COURSE OF ACTION:

- DOWNSIZED LASER SYSTEM (FY86)
- ENTER PROOF OF PRINCIPLE (FY87)
- MULTI-AGENCY STEERING COMMITTEE



#16

XM87 NBC RECONNAISSANCE SYSTEM (NBCRS)



TYPE CLASSIFY - 2QFY90

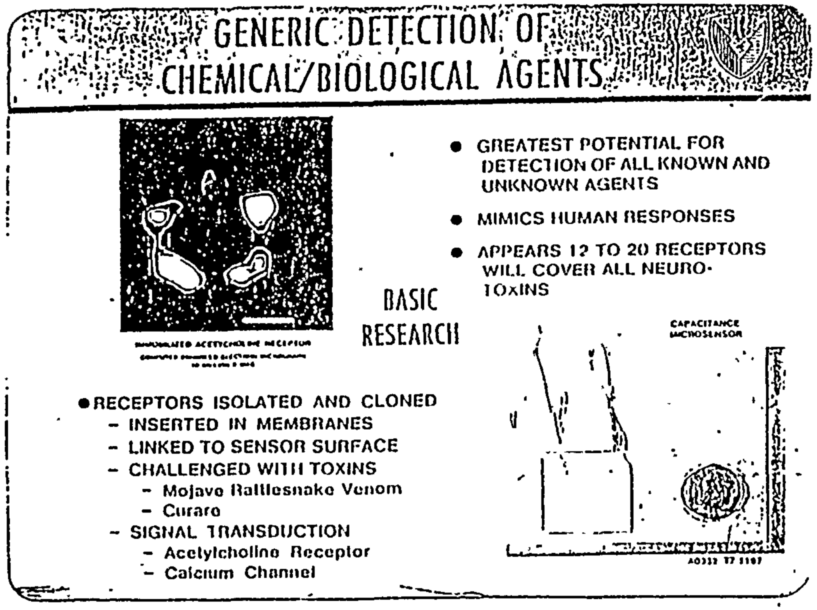
CONCEPT:

- PROVIDE ACCURATE AND RAPID NBC INFORMATION
- DEDICATED VEHICLE

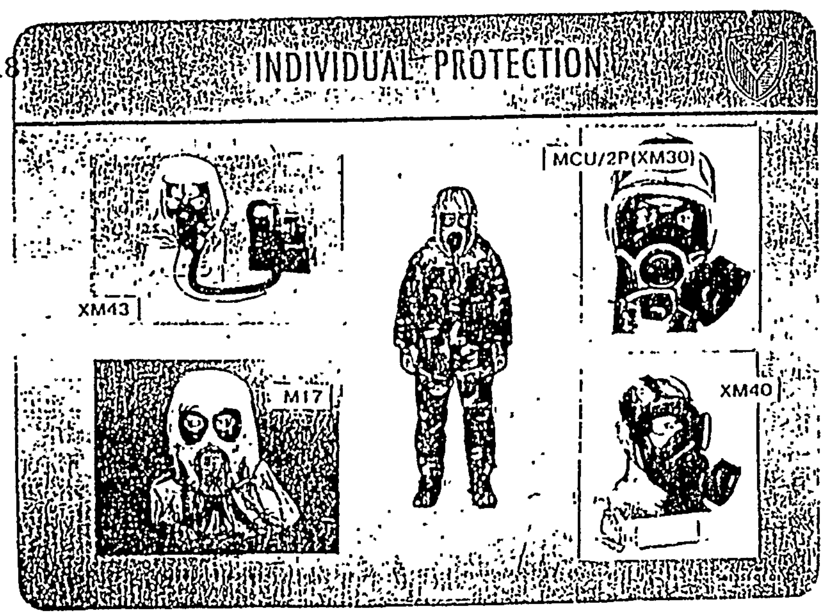
CAPABILITIES:

- INTEGRATED DATA ACQUISITION SYSTEM
- POINT AND STANDOFF CHEMICAL DETECTORS
- NUCLEAR DETECTOR
- MECHANIZED SURFACE SAMPLING
- MARK CONTAMINATION/ CLEAR LANES
- OVERPRESSURE WITH MICROCOOLING
- SAMPLE COLLECTION/ STORAGE
- DIGITAL BURST COMMUNICATIONS

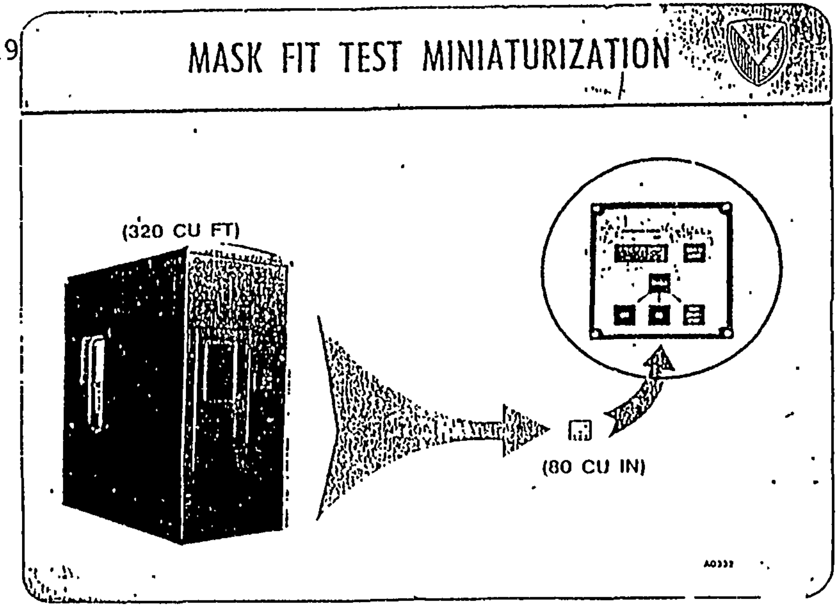
#17


GENERIC DETECTION OF
CHEMICAL/BIOLOGICAL AGENTS
BASIC
RESEARCH
● GREATEST POTENTIAL FOR DETECTION OF ALL KNOWN AND UNKNOWN AGENTS
● MIMICS HUMAN RESPONSES
● APPEARS 12 TO 20 RECEPTORS WILL COVER ALL NEURO-TOXINS
●RECEPTORS ISOLATED AND CLONED
- INSERTED IN MEMBRANES
- LINKED TO SENSOR SURFACE
- CHALLENGED WITH TOXINS
- Mojave Rattlesnake Venom
- Curare
- SIGNAL TRANSDUCTION
- Acetylcholine Receptor
- Calcium Channel
CAPACITANCE MICROSENSOR

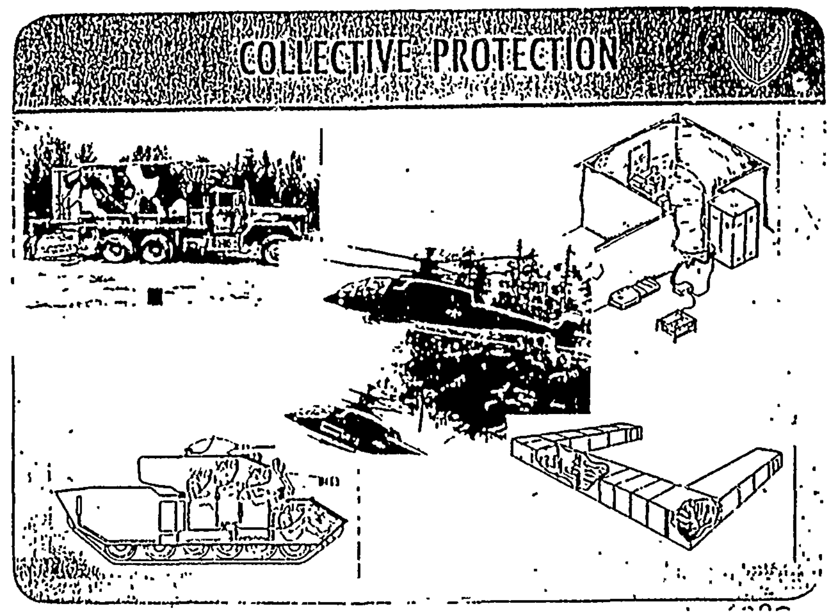
#18


INDIVIDUAL PROTECTION
XM43
MCU/2P(XM30)
M17
XM40

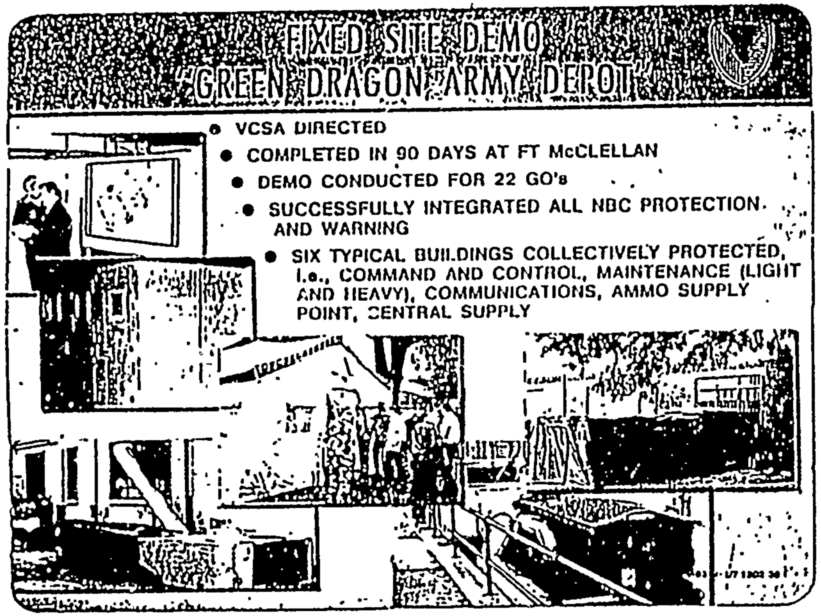
#19


MASK FIT TEST MINIATURIZATION
(320 CU FT)
(80 CU IN)

#20

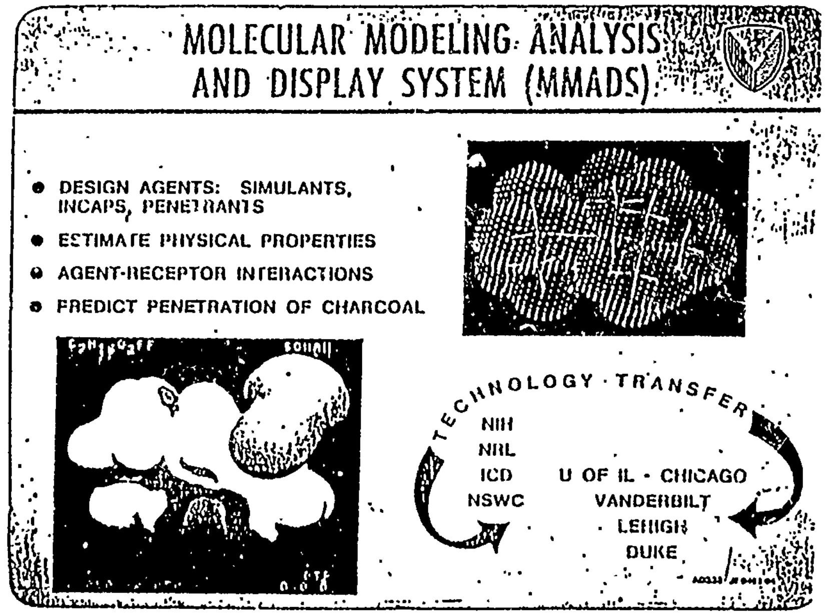

COLLECTIVE PROTECTION

#21



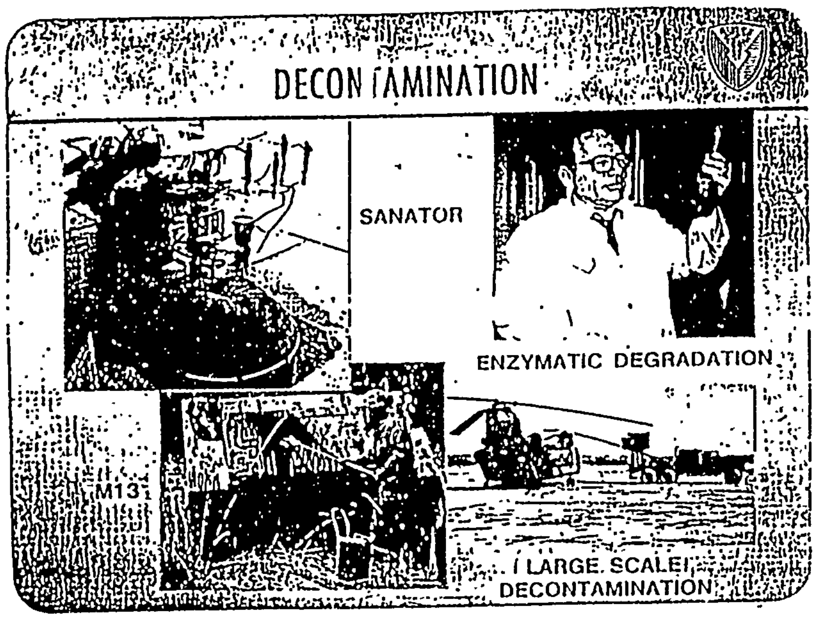
FIXED SITE DEMO
GREEN DRAGON ARMY DEPOT
VCSA DIRECTED
COMPLETED IN 90 DAYS AT FT McCLELLAN
DEMO CONDUCTED FOR 22 GO's
SUCCESSFULLY INTEGRATED ALL NBC PROTECTION AND WARNING
SIX TYPICAL BUILDINGS COLLECTIVELY PROTECTED, i.e., COMMAND AND CONTROL, MAINTENANCE (LIGHT AND HEAVY), COMMUNICATIONS, AMMO SUPPLY POINT, CENTRAL SUPPLY

#23



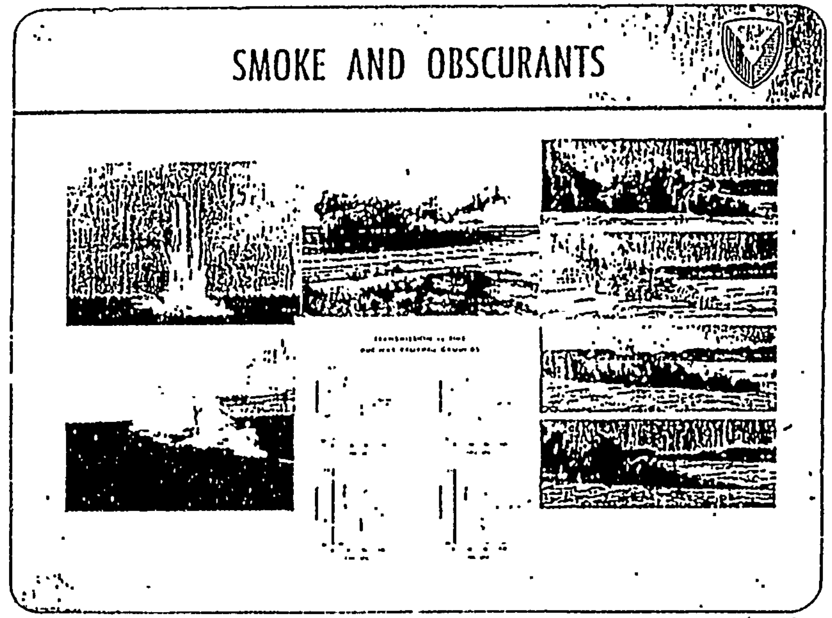
MOLECULAR MODELING ANALYSIS AND DISPLAY SYSTEM (MMADS)
DESIGN AGENTS: SIMULANTS, INCAPS, PENETRANTS
ESTIMATE PHYSICAL PROPERTIES
AGENT-RECEPTOR INTERACTIONS
PREDICT PENETRATION OF CHARCOAL
TECHNOLOGY TRANSFER
NIH
NRL
ICD
NSWC
U OF IL - CHICAGO
VANDERBILT
LEHIGH
DUKE

#22



DECONTAMINATION
SANATOR
ENZYMATIC DEGRADATION
M13
LARGE SCALE DECONTAMINATION

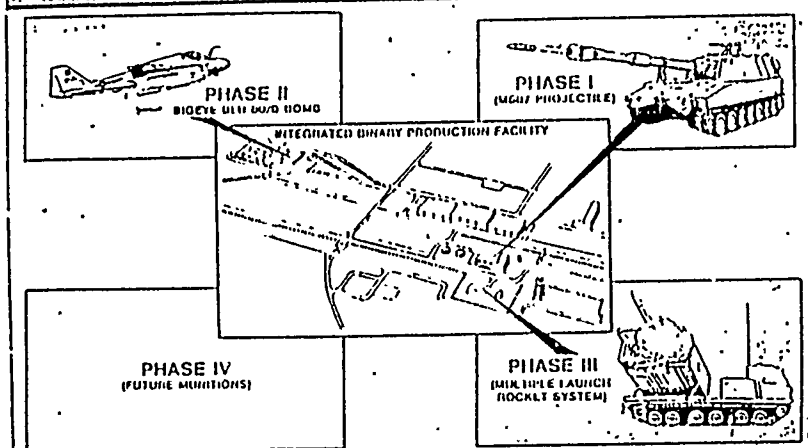
#24



SMOKE AND OBSCURANTS

#25

RETALIATORY CHEMICAL MUNITIONS



#26

TREATY COMPLIANCE VERIFICATION

- SHOULD BE TREATY ENABLING
- MAY PATTERN THE KIND OF TREATY THAT CAN BE WRITTEN
- DECLARED SITES:
  - REQUIREMENTS BEING DEFINED
  - ON SITE VERIFICATION TECHNOLOGIES ALMOST IN HAND
  - CONCERTED EFFORT CAN PRODUCE CAPABILITIES IN MID 1990
- UNDECLARED SITES/CLANDESTINE PRODUCTION:
  - VERIFICATION NOT CURRENTLY POSSIBLE, THIS IS THE CRITICAL CAPABILITY GAP
  - IMPROVED INTELLIGENCE GATHERING/PROCESSING CAN HELP
  - MUST PUSH REMOTE DETECTOR DEVELOPMENT

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PRIORITY TECHNICAL OBJECTIVES

- ACHIEVE TECHNOLOGICAL SUPERIORITY
- AVOID THREAT AGENT TECHNOLOGICAL SURPRISE
- REDUCE DEPENDENCE ON CHARCOAL
- IMPROVE PROTECTION AND REDUCE BURDEN
- ADAPTABLE MULTIAGENT DETECTORS
- ALTERNATIVES TO LETHAL AGENTS
- REDUCE LOGISTIC LOAD
- EMPLOY FRONT-END ANALYSIS AND PLANNING TO SELECT BEST-PATH TECHNOLOGY

U.S. NAVY CHEMICAL AND BIOLOGICAL (CB) DEFENSE PROGRAM

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The topics of the Navy's Chemical and Biological (CB) Defense to be discussed are: CB defense objectives, priorities and goals; CB defense acquisition strategy; overseas base surveys; and air-related programs.

The Deputy Chiefs of Naval Operations (CNO) for Naval Warfare and Surface Warfare are the major CNO sponsoring organizations. Requirements and resources flow from the Fleets through the CNO to the developing agencies. The Naval Sea Systems Command is the primary lead for Navy-wide advanced and full scale engineering developments.

Technology Base R&D is managed by the Office of Naval Technology and the Office of Naval Research. Only the Office of Naval Research works through academic institutions. All other development is through the Performing Activities. The lead laboratory for Chemical and Biological Defense Development within the Navy is the Naval Surface Weapons Center, located at Dahlgren, Virginia.

As with all other Services, the Navy complies with National Policy and Defense Guidance by requiring that: (1) naval forces be capable of surviving chemical and biological attacks, and (2) continue to operate in that environment. To attain those objectives, we first procured off-the-shelf items to achieve a survival capability. Chemical and biological systems development is specifically designed to meet shipboard requirements. Achieving sustained operational capability will require major breakthroughs in technology.

In 1982, the Chief of Naval Operations established the Navy's priorities for upgrading its chemical defense posture. The first priority for outfitting and R&D is the fleet. Overseas facilities follow.

The Navy's program is established to satisfy those operational objectives and priorities. The goal of the program is to provide survivability, operability, and sustainability for forces fighting in contaminated environments.

The Navy acquisition program strategy is to procure or develop CB defensive equipment and systems necessary to prepare us to survive and continue operations.

The Navy participates in the Joint Service Agreement signed in 1984. That agreement designates the U.S. Army as the Lead Service for multi-service CB research, development and acquisition. If a requirement is Service unique, such as for shipboard application, or the Army development program cannot provide for immediate needs, the Navy may pursue other options. Navy options are: off-the-shelf procurement; develop Navy unique or special application items; adopt another Service's solution; or use international development. In cases where the other Service's requirements do not satisfy Navy needs, particularly for shipboard applications, the basic program is adapted or modified to meet Navy requirements. Shipboard requirements differ so markedly from those of other Services that the Navy must conduct its own test and evaluation programs on all items prior to acceptance.

The U.S. Navy participates in NATO and other international programs. The Navy has delegates on all NATO chemical defense panels and committees. THe Navy also participates in multi-lateral agreements. Recent examples of international development adopted for the Navy are: the Mark III Protective Suit, adopted in 1984 as the U.S. Navy standard; the AR-5 Aircrew Mask, following intense test and evaluation, being procured for use by Marine Corps helicopter pilots. It is anticipated that, upon completion of shipboard test and evaluation, the Chemical Agent Monitor will be procured for Navy shipboard and shore base use.

The Navy acquisition program is focused in the following six major areas: CB defense architecture; individual and collective protection; CB agent detection; contamination control, materials and techniques; and training equipment.

The CB Defense architecture task provides a reference data base, design criteria, and the basis for a quick look at Technology Base candidates for advanced development.

Some examples of equipment evaluated under the individual and collective protection are: The United Kingdom's Mark III Suit and the MCU-2/P Mask. The MCU-2/P Mask effort is a joint Navy/Air Force development.

The prototype Collective Protection System (CPS) is installed aboard the U.S.S. Belleau Wood. This basic shipboard CPS design is being incorporated into the new guided missile destroyer class ship design. We are also developing CPS for ships that will not have full time systems.

The Navy is procuring Survivable Collective Protection Systems (SCPS) for overseas bases. A Navy prototype was tested at the Naval Air Station, Sigonella, Sicily in 1987. The first units will be procured in FY 88.

Our efforts in detection include: The Chemical Agent Point Detection System (CAPDS), a bulkhead sensor that detects nerve agent vapors; and an enhanced version, that detects nerve and blister vapors and aerosols and is due for Fleet introduction within the next five years. Fleet introduction of the Chemical Agent Monitor (CAM) is planned for FY 89. In addition, the Navy is participating in the evaluation of the Advanced Chemical Agent Detector and Alarm (ACADA) with the Army. The Chemical Warfare Directional Detector (CWDD) introduced into the fleet in 1983, is employed for detecting chemical agents at a distance.

Contamination control problems on Navy ships are similar to those on airfields. Once contaminated with liquid agent, we must decontaminate. Although the Navy, in its operating environment, has no shortage of water for decontamination, salt water poses its own problems as a corrosive. Currently, we plan to use contamination avoidance procedures and decontaminate only what is required for continued operations. The Navy is looking for a non-corrosive decontaminant for use with water washdown systems and a multi-use decontaminant to replace high test hypochlorite for shipboard use.

The next area, training equipment development, includes simulants and delivery devices to enhance shipboard and shore based training reality and effectiveness.

The CNO identified overseas bases as having a critical need for CB defensive equipment. Surveys were required to evaluate current capabilities and identify material and training needs. The Fleets established the priority for base surveys. Seventeen sites have been surveyed. Seven of those sites were air bases. Overseas naval airbases are designed for antisubmarine warfare and fleet support operations.

The approach to the surveys was based on these assumptions: that NATO standard contamination levels would occur; and that defense guidance for mission sustainability would be met. The survey team visited the bases and documented Navy-defined operational concepts and priority missions and functions. The missions and functions were examined to determine the following: susceptibility and vulnerability to chemical and biological attack; number of personnel requiring protection; required individual and collective protection based on mission functions; estimated impact of protection on mission accomplishment; decontamination and contamination control requirements; and medical support needs.

The post-survey analyses recommended the requirements for: detection and warning devices; chemical and biological defense equipment; stowage; maintenance; and training.

There are three major categories of ongoing Navy air-related programs. Air-capable ships are being analyzed to identify critical air-ship interface requirements. The contamination control equipment and techniques program is evaluating equipment and decontaminating materials. U.S. Air Force solutions in CB Defense R&D are an important source for Navy air program efforts.

In the future, the Navy CB Defense program will continue its efforts to develop improved chemical and biological warfare defense equipment and procedures for sustained mission effectiveness. Continued close coordination and cooperation between the Fleet representatives and the development community will assure more responsiveness to user needs. However, much remains to be done to meet the Defense Guidance requirement for sustained operations in a chemical and biological contaminated environment.

In conclusion, I would like to re-emphasize my major point: meeting the Navy's objectives requires major breakthroughs in technology.

U.S. AIR FORCE AIR BASE OPERABILITY (ABO) OVERVIEW

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Air Base Operability (ABO) is an integrated systems approach to sustaining operations before, during and after attacks directed against Air Force installations. The five major elements within ABO are defend, survive, recover, generate, and support.

"Defend" includes those air and ground defense actions necessary to counter hostile threats to our air bases, such as interceptor aircraft, surface-to-air missiles, and air base ground defense forces.

'Survive" takes in those actions that protect personnel, equipment and critical facilities. Examples include revetments, NBC hardening, and camouflage, concealment and deception.

"Recovery" deals with the rapid damage assessment and restoration of critical operations. Representative tasks include runaway repair, restoring utilities, clearing unexploded ordnance, and medical operations.

"Generate" deals with the launch and recovery of aircraft, such as the support of integrated combat turns and aircraft battle damage repair.

"Support" provides the personnel and resources needed to sustain the other ABO elements, including additive forces, War Readiness Material (WRM), communications, and transportation.

Department of Defense Instruction 4245.13
Design and Acquisition of
Nuclear, Biological and Chemical (NBC)
Contamination-Survivable Systems

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INTRODUCTION

The purpose of this paper is to provide the reader with a brief overview of a recently published Department of Defense Instruction (DoDI) entitled, "Design and Acquisition of Nuclear, Biological, and Chemical (NBC) Contamination-Survivable Systems," (DoDI 4245.13), dated June 15, 1987. It will cover the purpose of the instruction, along with its scope and applicability.

Before covering the specific features of DoDI 4245.13, it is appropriate to review quickly some of the key concepts that contribute to the overall subject of NBC survivability. There are four basic concepts:

o NBC contamination survivability, the concept which requires a system to withstand an NBC contaminated environment, including decontamination, without losing its ability to accomplish the mission;

o Decontaminability, which is comprised of several subelements. One involves the agent resistance of the materials used in the system. Decontaminability can likewise be facilitated by the design of the system to both enhance the ability of exposed surfaces to resist agent accumulation and to provide ready accessibility for decontamination operations.

Lastly, contamination control techniques, such as the use of over pressure, packaging, protective covers, and contamination avoidance all contribiute to decontaminability;

o Hardness is the inherent characteristic in the material of construction that makes a system resistant to damage by agents or decontaminants; and

o Compatibility, an NBC survivability concept which addresses the system interface with personnel wearing protective ensembles as well as other potential system-to system interfaces.

PURPOSE, SCOPE AND APPLICABILITY

DoDI 4245.13 is intended to provide general management and documentation requirements for the survivability of systems designed and acquired to perform mission essential functions in an NBC contaminated environment. It supplements existing acquisition directives such as DoD Directive (DoDD) 5000.1, "Major System Acquisition," DoDD 5000.2, "Major System Acquisition Procedures," DoDD 5000.3, "Test and Evaluation," and DoDI 4245.4, "Acquisition of Nuclear Survivable Systems." DoDD 5000.1 and DoDI 5000.2 are currently under revision in order to reflect changes in the acquisition process brought about by the DoD Reorganization Act which established the position of the Under Secretary of Defense for Acquisition (USD(A)). The revised versions of these documents should be available very soon.

The instruction applies to the Office of the Secretary of Defense (OSD), the Military Departments (Army, Navy, Air Force, and Marine Corps), the Organization of the Joint Chiefs of Staff (OJCS), and the Defense Agencies.

This instruction is intended to be used in conjunction with DoDI 4245.4. It calls for consideration of the effects of residual nuclear contamination as well as chemical/biological agents and decontaminants on the system under design. DoDI 4245.13 applies to all programs, systems, and subsystems designated as major system acquisition programs as defined in DoDD 5000.1, as well as any other program reviewed periodically by the Under Secretary of Defense for Acquisition under exceptional management procedures. Execution of the requirements of this instruction for nonmajor systems is the responsibility of the Services.

POLICY

It is DoD policy that NBC contamination survivability shall be included in the design and acquisition of systems that must perform mission essential functions in an NBC environment. This includes conventional forces, nonstrategic nuclear forces, strategic nuclear forces, special operations forces, and supporting command, control, communication, and intelligence systems.

RESPONSIBILITIES

DoDI 4245.13 levies specific responsibilities on the DoD components. The Under Secretary of Defense for Acquisition, through his cognizant Deputy Under Secretary or Assistant Secretary, and in coordination with the Assistant to the Secretary of Defense (Atomic Energy) (ATSD(AE)) may request an informal review of NBC contamination survivability on any major system at any time. The USD(A) may also elect to review the NBC contamination survivabiilty of supporting systems that must operate jointly in NBC environments.

The Office of the Assistant to the Secretary of Defense (Atomic Energy) (OATSD(AE)) acts as the office of primary responsibility for DoDI 4245.13 by virtue of the charter in another DoD Directive, 5148.2, which addresses the responsibilities of the ATSD (AE). The ATSD(AE) is solely responsible for advising the Defense Acquisition Board (DAB) on the adequacy of NBC contamination survivability programs.

The Deputy Under Secretary of Defense (Test and Evaluation) (DUSD (T&E)) shall confirm that NBC contamination survivability objectives are met during acquisition test and evaluation. The Director of Operational Test and Evaluation (DOT&E) shall evaluate the operational effectiveness and suitability of NBC contamination survivability measures against defined operational requirements.

The bulk of the responsibilities for carrying out this instruction fall upon the DoD components. These responsibilities include:

o Assessing NBC contamination survivability and identifying vulnerabilities and associated risks for systems with NBC contamination survivability requirements;

o Presenting to the DAB at Milestone 1 the cost and operational trade-offs of achieving NBC contamination survivability;

o Ensuring that nonmajor mission essential systems are scrutinized closely for potential impacts on mission essential functions;

o Developing and employing procedures similar to those contained in DoDI 4245.13 to ensure that nonmajor mission-essential systems exhibit appropriate NBC contamination-survivability.

o Advising the USD(A) at each milestone review if another major or nonmajor system has become a critical survivability limitation in the operation of the major system under development. For instance, it would be inconsistent to design an advanced tactical fighter to meet NBC contamination survivability criteria without designing comparable NBC contamination survivability requirements into the supporting aircraft generation equipment; and

o Developing NBC contamination survivability criteria and standards to submit to the USD(A) for review. This last responsibility will no doubt generate considerable discussion among DoD components. Should the criteria result in conflicting requirements, they will be referred to the OATSD(AE) or, if necessary, the DAB for resolution.

PROCEDURES

How is the goal of achieving NBC contamination survivability to be attained? There are a variety of procedures that can be followed to ensure that NBC contamination survivability is given proper attention in the design and acquisition of weapons and support systems. Some of the procedures are rather obvious from the start and others will be fine tuned as the development and acquisition process proceeds and DoDI 4245.13 matures. NBC contamination survivability is not really a new concern to those who have worked in this area before. Nuclear survivability has been addressed in DoDI 4245.2 since 1983. Chemical contamination survivability, while formalized by DoDI 4245.13, has not been ignored by the chemical community. In 1985, the Army's Chemical Research, Development and Engineering Center published an NBC survivability handbook. The Air Force has also sponsored work in putting together an extensive data base on the resistance of materials to chemicals and chemical agents. The Defense Logistics Agency has recently contracted with Battelle Columbus to set up and operate a full service Chemical Warfare/Chemical Biological Defense Information Analysis Center that can help address many NBC survivability questions.

However, the lever to cause the defense community as a whole to address the critical issue has been absent. In 1983, the ATSD (AE) addressed the subject in a letter to DoD components. The contents of that guidance were for the most part ignored.

The procedures established in DoDI 4245.13 to ensure that NBC contamination survivabilty is addressed in major and nonmajor systems are as follows:

o Emphasis will be placed on employing a proper combination of cost-effective survivabilty techniques, not just NBC contamination survivability of individual force elements. Within these combinations of techniques are included materials and coatings that resist or minimize absorption of NBC contamination and/or facilitate rapid decontamination; designs that resist accumulation of NBC contaminants on exposed surfaces and/or that are readily accessible for decontamination; and devices and procedures that reduce personnel/system contamination hazards by lowering NBC contamination levels and/or preventing the spread of NBC contamination;

o Emphasis will also be placed on recognizing the systems' contribution to the success of a much larger wartime function. Such functions often require a combination of different major systems and other elements to operate together to ensure function or mission completion. Program managers should attempt to balance the survivability of the system under development with all systems that must function to accomplish the mission;

o NBC contamination survivability requirements are to be defined using system performance and environmental criteria and design specifications that are insensitive to minor changes in threat environment. Agreement on the definition of these criteria and specifications may not be an easy task. Within the nuclear community, the Defense Nuclear Agency arbitrates such disagreements. Nevertheless, Service disagreements on nuclear survivability issues are not always arbitrated to the complete satisfaction of all concerned. There is no Defense Chemical Agency;

o NBC contamination survivability will be validated and confirmed through a combination of realistic testing, simulation testing, and analysis such as currently available to DoD components at the Army's Dugway Proving Ground in Utah.

o Services will establish procedures for survivability reassessments during the systems' life cycle. As a minimimum, survivability should be reassessed in conjunction with major modifications, changes in mission, or changes in threat;

o Acquisition strategies shall accommodate an NBC contamination-survivability maintenance and surveillance program to support the operational phase of life-cycle NBC survivability; and o The DAB process shall include a careful examination of the systems' NBC contamination survivability and the potential impact of each system on larger wartime functions.

To ensure that NBC contamination survivability requirements are addressed during the design and acquisition of weapon systems, specific documentation will be required.

INFORMATION REQUIREMENTS

DoDI 4245.13 specifies that the Justification for Major System New Start, the System Concept Paper, and the Decision Coordinating Paper, as defined in DoDI 5000.2, shall include NBC contamination survivability management level summaries and resource allocation summaries. It further calls for plans to validate and confirm NBC contamination survivability, to include specification of adequate resources for test and evaluation. These resources are to be documented for major and designated weapon systems in the Test and Evaluation Master Plan as outlined in DoDD 5000.3. In addition, each DoD component shall include an NBC contamination survivability status summary as a part of the scheduled test and evaluation briefing given 15 days before a DAB meeting according to the Milestone Review Process specified in DoDI 5000.2 and DoDD 5000.3.

IMPLEMENTATION PLAN

DoDI 4245.13, as of the date of publication, applies to all major systems with NBC contamination survivability requirements that have not entered into demonstration and validation phase (Milestone I). For those systems that have passed Milestone I but not Milestone II as of June 15, 1987, each DoD component will implement DoDI 4245.13 and report to the USD(A) within 12 months on major acquisitions and modification programs for DAB reviewed major systems with NBC contamination survivability requirements. DoD components will also conduct a one time assessment of all DAB reviewed major systems having NBC contamination survivability requirements which have had a Milestone II review but have not had a Milestone III review as of June 15, 1987. The results of this one time review will be submitted to the USD(A) by December 15, 1987. Finally, each DoD component is expected to forward a copy of their implementing documents for DoDI 4245.13 to the USD(A) by Septmber 15, 1987.

THE LONG FIRST STEP

The publication of DoDI 4245.13 represents a long awaited and difficult first step in trying to improve this country's warfighting capability. The mere publication of the instruction does not guarantee achievement of NBC contamination survivability. Much work remains. With NBC contamination survivability as the goal that sits on the horizon, the path from this instruction to that goal has to be a stair step approach. Some steps will undoubtedly be longer than others while some steps will be higher than others. As the defense community wrestles with the difficult requirements associated with implementing DoDI 4245.13, some of those longer or higher steps may have to be broken down into more manageable and better defined objectives. As always, factors such as the evolving threat, risk assessment, cost effectiveness, schedule, etc., will weigh into the decisions affecting NBC contamination survivability.

The longest journey begins with the first step. That step has been taken.

ACRONYMNS

ASD	Assistant Secretary of Defense
ATSD	Assistant to the Secretary of Defense
DAB	Defense Acquisition Board
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DOT&E	Director of Operational Test and Evaluation
DUSD	Deputy Under Secretary of Defense
NBC	Nuclear, Biological, and Chemical
OATSD	Office of the Assistant to the Secretary of Defense
OJCS	Organization of the Joint Chiefs of Staff
OSD	Office of the Secretary of Defense
T&E	Test and Evaluation
USD(A)	Under Secretary of Defense for Acquisition

NBC CONTAMINATION SURVIVABILITY

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1.0 Introduction

It is certainly difficult and probably presumptuous to attempt to do justice to the topic of NBC contamination survivability in a short paper such as this. The difficulty arises from the complexity of the issue, and the presumptiveness stems from the wide-scoping nature of the topic. Moreover, many notions abound on just what is meant by survivability. What is presented here is just one of many approaches. As the field matures there will undoubtedly be many evolutionary changes. However, in any case this serves as an instructive basis upon which modifications may grow. Although the term survivability is used throughout this paper, keep in mind that the ultimate goal is to effect sustainability of mission operations in NBC contaminated environments, not just survivability.

2.0 Overview

Essentially, comprehensive survivability consists of 3 main considerations: Threat/Challenge/Hazard, Simulation and Hazard Management.

2.1 Threat/Challenge/Hazard

The trifold component, Threat/Challenge/Hazard, defines the problem to be addressed. Little will be said on the threat other than that potential adversaries possess weapon systems which could produce NBC contaminated environments. The Challenge is a quantitative characterization of these environments, and the Hazard is a quantitative characterization of the responses of personnel and materiel to such conditions. In short, Challenge is the cause, and Hazard is the resultant effect.

2.2 Simulation

Simulation ranges the spectrum from computer modeling to use of simulants for trialing and training. As such, it enables both practical exericising of concepts and discerning of parametric sensitivities.

2.3 Hazard Management

Hazard Management encompasses the tools available to commanders for use in actual contaminated environments. It consists of 2 sub-areas, one dealing with all the traditional components of what may be called an integrated NBC defensive system and the other dealing with features of virtually all other military materiel.

2.3.1 Integrated NBC Defense System

The integrated NBC defensive system is "visible" to the personnel at the time of use. One breakdown of the system is based upon the following functions:

Intelligence: downwind plots, reconnaissance

Medicine: pre-treatment, therapy

Detection: alarm/warning, identification, reconnaissance, monitoring

Individual Protection: eye/respiratory, body/appendages

Collective Protection: air purification, ingress/egress

Contamination Control: avoidance/suppression, decontamination, demolition

Deterrence/Retaliation: unitary/binary munitions, weapon systems

Although considerable detail has gone into design and engineering of items/systems for each of these components, 2 levels of integration have been less well addressed. The first deals with combining the components into a truly integrated NBC defensive system. Desirable characteristics for each have been reasonably well identified and actually achieved. However, no comprehensive assessment of the advantages/disadvantages of each in the context of a whole system has been made to allow realistic tradeoffs for use in actual NBC environments. In short, the approach has been largely *ad hoc* and piecemeal. The second level refers to integration of such an NBC integrated defensive system into the overall military posture. NBC defense equipment is often added to other materiel as an add-on, not as a built-in system. Also, the NBC defense equipment is assigned the task of making the contaminated environment "invisible" so that operations may proceed in a "business as usual" attitude. Proper integration of both NBC items and their use into general operations (with some modification undoubtedly) would ameliorate the impact of many perceived limitations.

2.3.2 NBC Contamintion Survivability

Traditionally everything so far addressed in this paper has been considered to be NBC Contamination Survivability. Unfortunately, the other main sub-area of Hazard Management has also been given the same name. Therefore, it is suggested that the entire topic, including Threat/Challenge/Hazard, Simulation, and Hazard Management be called Comprehensive or Global NBC Contamination Survivability and this sub-area of Hazard Management be called simply NBC Contamination Survivability. In any case, that is the approach taken in this paper.

This sub-area of Hazard Management, unlike the other, is "invisible" to users in contaminated environments. It is an implementation of a philosophy which has been likened to the use of "building codes" in the construction of architectural structures. Just as plumbing, wiring, structure, etc., codes require health, fire, safety, earthquake, etc., principles to be addressed in the construction of buildings, this issue of NBC Contamination Survivability requires certain principles to be addressed in the fabrication of military materiel.

Therefore, the 2 aspects of Hazard Management complement each other: the Integrated NBC Defensive System deals with NBC materiel and NBC Contamination Survivability deals with all other materiel.

3.0 Elaboration on NBC Contamination Survivability

3.1 Background

On 1 May 1984 the United States Army initiated a formal program on the sub-area of Hazard Management called NBC Contamination Survivability with the publication of Army Regulation (AR) 70-71, Nuclear, Biological, and Chemical Contamination Survivability of Army Materiel. This regulation has its roots in several international programs, including some early discussions in NATO Panel VII dating from the late sixties. AR 70-71 requires that NBC Contamination Survivability be addressed in all programs for mission essential materiel. On 15 June 1987 the United States published Department of Defense Instruction (DODI) 4245.13, Design and Acquisition of Nuclear, Biological, and Chemical - (NBC) Contamination Survivable Systems, formally requiring the Army's sister Services to institute similar programs. This paper is intended to acquaint the NATO nations with the provisions of AR 70-71 (and DODI 4245.13) and some of the experiences and difficulties in implementation. It is not intended as a recipe book. The emphasis is to provide an overview together with insights to both positive aspects and difficulties confronted.

3.2 Philosophy

Prior to the adoption of AR 70-71, consideration of NBC survivability was essentially ad hoc and only loosely coordinated. Requirements documents for items and systems, although by regulation containing NBC-related statements, were only generally worded. Moreover, the NBC statements were given low priority within the context of the overall document. The result was type classification of the items or systems with little concern for NBC matters. Eventually, when and if systems were tested for NBC vulnerability, identified deficiencies had to be addressed on an ad hoc basis of retrofit and/or introduction of new NBC equipment. The consideration in this way fostered a proliferation of specialized solutions.

AR 70-71 addresses the above in several ways. Definitive, quantitative characteristics for systems are overtly stated for incorporation throughout the life cycle of the systems. The process begins at the earliest stages of research and development. Perhaps, most importantly, the emphasis is shifted from evaluation for vulnerability to design for survivability in NBC environments.

3.3 Provisions

AR 70-71 establishes policy and procedures to ensure that the survivability of selected Army materiel exposed to an NBC environment is considered from the earliest stage of the acquisition cycle, reasonable mission-related criteria are used to assess survivability, and these criteria as used in the research and development phase of materiel development are continued to be used or refined throughout the production and deployment phase. These criteria cover commercially-procured items, system retrofits, modifications of existing item specifications and, under appropriate conditions, waivers.

The regulation applies to mission essential materiel defined to be that which is necessary to accomplish the primary or secondary functions of the military unit.

For the purpose of the regulation, nuclear (N) refers to residual radiological contamination consisting of fallout, rainout and neurton-induced gamma activity. The initial nuclear effects of air-blast, thermal stress, electromagnetic pulse and initial nuclear radiation are addressed by the complementary AR 70-60. Biological (B) refers to all the general classes of micro-organisms and toxins that can be used as biological warfare agents. These classes include bacteria, rickettsia, viruses, fungi and microbial toxins. Chemical (C) refers to all known chemical warfare agents including blood agents such as AC, nerve agents such as VX, GB, and thickened GD; and blister agents such as HD.

NBC Contamination Survivability is defined as the capability of a system and its crew to continue operation in an NBC-contaminated environment, including decontamination, without losing the ability to accomplish the assigned mission. The characteristics of survivability include decontaminability, hardness (to both decontamination and agents), and compatibility for persons wearing the full NBC protective ensemble. Each of these characteristics will be elaborated on in succeeding sections of this paper.

4.0 NBC Contamination Phenomenology

4.1 NBC Environment

Although herein treated separately, each of the types of contamination can obviously occur in any combination on future battlefields. Synergistic effects are suspected, but little sound data exist.

Three broad categories of effects must be considered. One is the anti-personnel effect of agents, fallout/rainout and induced gamma radiation. The second is the degradation to materiel from interaction with the agents, fallout/rainout, induced gamma radiation and decontamination procedures and materials. The third is the degradation to performance of individuals owing to wearing individual protective equipment. An ancillary consideration, which impacts on all the above, is the transfer of contamination from place to place.

4.2 Anti-Personnel Effects

These effects are functions of several characteristics including contamination density (usually expressed in g/m^2) drop/particle size distributions, nature of the contaminated surface, environmental conditions (i.e. temperature, wind speed, relative or absolute humidity), time since contamination occurred, and type of contamination. Physiological responses are functions of the mode of entry to the body, time of exposure, type of contamination, and flux to the body (usually expressed in amount per unit area per unit time). All these factors become important in ascertaining survivability and will be referred to when considering decontaminability in detail.

4.3 Degradation of Materiel

Degradation effects, like the anti-personnel effects, are functions of contamination density, drop/particle size distributions, environmental factors, time of exposure, flux, and "spread factors." Dose-response curves play a role but are less well-documented than in the anti-personnel case. Of particular concern are the results to materials owing to long-term, non-catastrophic exposures and long-term effects to materials stressed for a short time by massive contamination and/or decontamination. All these will be referred to when considering hardness.

4.4 Performance Degradation from Protective Equipment

When wearing a protective ensemble, an individual suffers decrements to the many ways of being coupled to the environment. Oral/aural decrements degrade communications. Mechanical decrements degrade tactility, sensitivity for fine work, accessibility in reach and flexing, and time to perform tasks. Material exchange decrements degrade normal body functions such as perspiring, defecating, urinating, feeding and breathing. Thermal decrements produce heat stress. Visual decrements degrade many military tasks such as aiming, target indentification, and operation of equipment. All these will be referred to when considering compatibility.

5.0 Principles

5.1 Decontaminability

Decontaminability is the ability of a system to be rapidly decontaminated to reduce the hazard to a negligible level for unprotected persons who operate, maintain, and resupply it. Decontaminability refers to the residual hazard to personnel. Many factors need to be specified in order to formulate a workable scheme for this provision:

- Level of initial contamination
- Time the contamination remains on the item
- Exposure conditions
- Decontamination procedure, materials and equipment used
- Time allowed for decontamination
- Level to which item is decontaminated

For the purposes of AR 70-71 the values for these factors were chosen to provide reasonable assurance that the item is decontaminable. Controversy surrounds nearly each value chosen owing to 3 concerns. Concern has been expressed that the initial contamination level does not match threat assessments, that the decontamination scenario is too stylized to mimic actual field conditions, and that the negligible risk levels chosen for the endpoint of decontamination are unreasonable.

Arguments for the values are based, however, on the philosophy that these are test conditions, not emulations of actual field conditions. They are not to be construed as doctrinal conditions for operational consideration in the actual conduct of war.

However, even if such criteria are accepted as test conditions only, other concerns immediately arise. The initial contamination levels for exterior contamination are given as area densities (i.e. either number or mass per unit area). For nuclear fallout and biological spores, other determinants such as particle sizes, etc., are fairly straightforward values derived from actual tests or known innate physical properties. For chemical contamination, droplet sizes (and distributions) are less well established but extremely important. Decontamination effectiveness and persistency (as affected by evaporation and sorption into materials) are strong functions of droplet sizes and distributions. Also, little data exist on the amount and form of contamination transported to interiors by actual transfer, condensation, etc. Studies are continuing to establish such values for use in decontaminability testing.

For negligible risk values, very little human test data are available. The bulk of the literature consists of qualitative information, animal test data and acute exposures. Hence, confident values are simply not available. Also, the values for residual liquid contamination expressed as amounts per person or per mass of body weight are difficult to relate back to amounts per unit area of contaminated materiel. Unknown are contact hazards associated with materials which contain sorbed agent but no free-standing liquids. Fluxes from such materials, contact areas and nature of the contacting skin are difficult to quantify. Cooperative research efforts are needed to address these issues.

These problems notwithstanding, the question of decontaminability is being addressed by providing guidance to developers of military materiel through handbooks. One handbook provides information on designs which ease the decontamination task by minimizing the chance for free-standing liquid contamination to exist after decontamination. Another handbook provides information on agent sorption characteristics of materials of fabrication and coatings.

This guidance on materials is also important for neutron-induced activity in an item surviving the initial effects of a nuclear detonation. The item must not be constructed of materials which will have a residual-induced radioactivity owing to creation of radioisotopes by an initial fluence of neutrons.

Standardization of tests is of prime importance to allow exchange of data and partitioning of the huge number of materials to be tested among the nations. Research efforts are also continuing on fundamental studies of agent properties which control sorption or transfer from surface to surface. These efforts have the goal of providing an understanding of the materials/agent interactions in order to allow selection or development of the best materials. Also, the development of appropriate simulants requires this type of knowledge.

5.2 Hardness

Hardness is the capability of withstanding the collateral materiel-damaging effects of anti-personnel NBC contamiantion and the procedures/materials required to decontaminate the item. As contrasted to decontaminability which was stated to be concerned with residual hazards to personnel, hardness concerns damage to materiel.

For AR 70-71 hardness is stated as the capability to suffer no more than a 5 percent decrement in selected, quantifiable, essential characteristics over a 30-day period owing to 5 exposures to NBC contaminants, decontaminants and decontamination procedures. Unfortunately, the materials/agent/decontaminant/procedures interactions studies in the past concerned mainly catastrophic effects. Tests were usually of relatively short duration and semi-quantitative, at best. The data base on materials for storage of agents and decontaminants, for example, is small and involves special and costly materials unsuitable for general use. Also, testing usually concerned a very small number of interaction properties.

Long-range (i.e., 30-day) tests are just beginning to provide data for inclusion in the aforementioned materials handbook. However, no clear-cut set of properties to be tested has been established, nor have truly representative test methodologies been establsihed.

Work is also continuing on a vulnerability model which can determine the percentage degradations in the selected, essential characteristics in terms of material, component, sub-component and systems tests.

5.3 Compatibility

Compatibility is the capability of an item or system to be operated, maintained and resupplied by personnel wearing the full NBC protective ensemble in all climatic conditions for which it is designed and for a period specified in the requirements document. An important factor is that collective protection equipment (CPE) can be used in lieu of compatibility. To do so, however, entertains the risk of crew degradation should contamination enter the CPE protected zone and force the crew to don the NBC protective ensemble.

This compatibility provision forces the design of military materiel which takes into consideration the combination of equipment and anticipated NBC protection. This combination permits performance of mission-essential operations, communications, maintenance, resupply and decontamination over a 12-hour mission under environmental conditions of areas of intended use with no more than a specified degradation of crew performance below levels specified for these tasks accomplished in a non-NBC environment.

The specified decrement, although stringent, was selected to force the community at large to address this issue from the start in the design of new military systems and NBC ensembles.

6.0 Conclusion

This paper has presented the concepts of NBC Contamination Survivability as detailed in AR 70-71 (and DODI 4245.13) within the larger context of Comprehensive or Global NBC Contamination Survivability.

Now that the characteristics of NBC survivability have been detailed and certain concerns aired, it is perhaps prudent to consider some general aspects. As those of us in the NBC community step forward in the survivability field, we should heed a criticism made about an allied field of endeavor, the practice of medicine. A paraphrase of this criticism is that the trouble with medical practitioners is their preoccupation with illness rather than health. As we in NBC survivability proceed with filling the data gaps and performing the necessary testing, let us not fall back into defining vulnerability and _ad hoc_ cures to several decimal points, but let us emphasize prevention of difficulties and maintenance of survivability as our standards.

Given infinite money and time, the problems can be solved or, at least, minimized. However, resources are limited. Therefore, trade-off evaluations will most assuredly have to be made. We must establish rational principles to determine cost effective, balanced surviability.

Operational Analysis - An Overview

Dr. John T. Bartlett
CDE Porton Down, UK

If we are able to maintain airborne operations in a chemical environment without overloading some elements of the system, it is essential to carry out some detailed operational analysis of the various stages involved in generating effective sorties and to examine the way in which they are likely to be affected when personnel are compelled to wear protective equipment.

One approach to carrying out such studies is described and it is argued that what is needed is an interaction between studies and trials so that effort can be concentrated on filling the most critical data gaps.

It is further argued that the output from such studies should lead to a) identification of the best drills and procedures for work in a chemical environmental; b) more effective training for work in that environment; and c) recommendations on the most cost-effective way of equipping bases to operate in that environment, as well as to overall appreciation of the impact of chemical warfare (CW) on sortie generation rates.

USAF/NATO Conference "Maintenance of Air Base Operations in a Chemical Warfare Environment"

Base Recovery After Attack (BRAAT) Training

Briefing Paper Material
Briefer: LtColonel Horst G. Haeusser

The Soviet/Warsaw Pact forces pose a challenging threat to USAF bases overseas. As a result, base recovery operations will have to be coordinated and personnel in various specialties must be able to work together to conduct a rapid and effective recovery. The Engineering and Services forces deploying from the Continential US (CONUS) must know how to operate in accordance with theater procedures.

The BRAAT Program conducted by Detachment 2 of the Air Force Engineering and Services Center at Eglin AFB FL provides this needed training. Engineering and Services, Disaster Preparedness, and Explosive Ordnance Disposal personnel have the opportunity to train together in a realistic wartime environment. Functional skill and integrated or common training provide students with information they need to know to survive and operate effectively when deployed. Classroom time is kept to a minimum and hands-on training is stressed in all courses.

Engineering and Services students train on all three approved methods of rapid runway repair, and practice multicrater repairs using theater-unique equipment like excavators and concrete saws. Functional training includes topics such as European utility systems and installation of new aircraft arresting systems. A command and control course provides officers and senior NCOs the training needed to effectively assess, analyze, and coordinate recovery operations. Officer students also practice on-site command and control of multicrater repairs.

The Disaster Preparedness students learn how to use state-of-the-art chemical/biological detection equipment and high threat area detection and warning concepts. They receive training on camouflage, concealment, and deception techniques, collective protection, wartime planning and command post operations. EOD personnel train with EOD-specific equipment, including the ordnance rapid area clearance (ORACLE) system and participate in damage assessment team operations.

Two days of field exercises, including both day and night operations provide realistic, integrated training opportunities unavailable anywhere else in THE CONUS. During these exercises, students in each functional area not only practice technical skills they learned during the first days of the training deployment, but also work together as a team ، conduct base recovery operations.

The BRAAT training program provides our CONUS deploying forces with the knowledge they need to survive and operate effectively in wartime.

COMMANDERS' GUIDE FOR OPERATING IN A CHEMICAL ENVIRONMENT

Major Craig A. Reichow
NBC Staff Officer
Air Base Operability System Management Office

A panel of former U.S. Air Force - Europe (USAFE) Wing Commanders and Senior Wing Staff members prepared a short, 13 - page guide for current commanders and senior wing/unit level decision makers. This guide provides insight into the problems of operating in a chemical warfare environment. Specifically, the guide focuses on those chemical defense-unique aspects of fighting the battle from a central European main operating base (MOB). Many aspects of the guide can be adapted for virtually any other situation.

The guide is solution oriented and designed to be a thought stimulator instead of an all-inclusive guide or checklist. The guide contains section of the threat, current capabilities, and an extensive section on operational considerations. The guide urges commanders to exercise longer and more realistically, think of both chemical and conventional hazards, and look for ways they can work in a chemical warfare environment.

NOTE: Copies of the "Guide" were available at the conference site for conference attendees. Distribution of the guide is authorized to US government agencies, their contractors, and NATO government agencies only. Request for the guide should be referred to:

AD/YQ
Eglin Air Force Base, FL 32542-5000

Medical Aspects of Chemical Warfare: Operational Reality

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Department of Military Medicine
Uniformed Services University of Health Sciences
Department of Defense

The integrated modern battlefield - conventional plus chemical weapons - poses significant problems for field medical systems, both from the standpoint of unit survival and the provision of emergency care and evacuation. This situation is described beginning with the most forward medical echelon - the individual soldier and combat medic - and moving retrograde through pre-hospital echelons.

Issues of self-diagnosis and self-treatment with antidote by troops in combat are discussed as are the problems confronting small unit commanders (platoon and company), and medical personnel in pre-hospital echelons. Problems in handling a casualty of various types and degrees of severity, in addition to the usual spectrum of combat injury and disease, are discussed.

In the context it is clear that research personnel must establish and maintain a dialogue with the medical and combat arms officers who will have to use the products of research to accomplish their mission in wartime. Research which is conducted in ignorance of the operational reality of combat on the integrated battlefield is unlikely to result in products of significant utility to the user. Suggestions for initiating and expanding meaningful communication among research personnel, military medical officers and operational force commanders are provided.

THE ROLE OF THE NUCLEAR, BIOLOGICAL AND CHEMICAL OPERATIONS INTERSERVICE WORKING PARTY (NBCOIWP)

MAJ Robert J. Kainz, ScD
U.S. Army Nuclear and
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ABSTRACT

Meeting the Soviet threat in Europe requires NATO allies to conduct operations as a single force. The period of warfare where national forces maintained their own operational sectors has passed. The means NATO allies use to reach the desired level of compatibility and interoperability among member nations is through the Military Agency for Standardization (MAS). A vital link to resolve operational NBC non medical issues between U.S. Services and the MAS is the NBCOIWP.

Twenty-five times since World War II, the working party has met. Composition of the working party includes all NATO Member Nations as well as all NATO commands. Emphasis in the working party is shifting from nuclear to chemical issues. Limited discussions occur regarding biological defense.

At present, the NBCOIWP administers a total of 22 STANAGs; 15 have been promulgated, 2 are as drafts and 5 have been proposed. The U.S. is the custodian of 8 of these STANAGs.

NBC operational issues which a Service desires to be addressed by NATO may be surfaced through the NBCOIWP. Services communicating through the U.S. Representative or DOD Action Agent have a direct voice in NATO planning and decisions. Participation in the working party at the U.S. level is unlimited. This paper deals with only one aspect of NATO's complex organization, the role of the NBCOIWP.

INTRODUCTION

The North Atlantic Treaty is the framework for a defensive alliance designed to prevent aggression or to repel it should such occur. It provides the forum for continuous cooperation and consultation in political, economic and other non-military fields. The Treaty is of indefinite duration.

The North Atlantic Treaty brought into existence an alliance of independent countries militarily prepared to maintain the peace, defend freedom and foster stable worldwide relations. The Alliance is an association of free states joined together to preserve their security through mutual guarantees and collective self-defence. NATO is not a supranational organization. It is a international in which member states retain their full sovereignty and independence. The organization provides the forum in which they consult and reach decisions on political and military subjects. On the political side they coordinate their security policies in accordance with the goals of the North Atlantic Treaty. On the military side they formulate joint defence plans, establish the infrastructure needed to enable their forces to operate; and arrange for joint training programs and exercises. The forces of NATO countries remain, as a rule, under national authority.

The Alliance guarantees the security of its members through a policy based on the two principles of defence and detente; it does not seek to base its security on military strength alone. The member countries maintain adequate defence and political solidarity in order to ensure credible deterrence while at the same time seek a constructive East-West relationship through dialogue and mutually advantages cooperation, including efforts to reach agreement on equitable and verifiable arms reductions. These elements are complementary; dialogue can only be fruitful if each party is confident of its own security and is prepared to respect the legitimate interests of others.

NATO DEFENSE POLICY.

The primary role of the Alliance is to safeguard the security of member nations by deterring aggression. This means that a potential aggressor should have no doubt that if he initiates an attack against one member nation, the other member nations will come to the threatened member nations's aid. Therefore, he (the enemy) will be taking a risk out of all proportion to any advantage he may hope to gain. In the event of aggression, the role of the Alliance is to re-establish the territorial integrity of the North Atlantic area. NATO must therefore maintain sufficient forces to preserve a military balance with the Warsaw Pact and to provide a credible deterrent. NATO's strategy of flexible response adopted in 1967 means that the Alliance must have sufficient forces to respond to any level of aggression and must possess a full spectrum of forces so that it can counter any act of aggression with an appropriate response.

NATO forces are made up of three interlocking elements known as the NATO Triad. They are:

- -conventional forces strong enough to resist and repel a conventional attack on a limited scale; and to sustain a conventional defence in the forward areas against large-scale conventional aggression;
- -intermediate- and short-range nuclear forces to enhance the deterrent and, if necessary, the defensive effort of NATO's conventional forces against a conventional attack; to deter and defend against an attack with nuclear forces of the same kind; and to provide a linkage to the strategic nuclear forces of the Alliance with the aim of convincing an aggressor that any form of attack on NATO could result in very serious damage to his interests and of emphasising the dangers implicit in continuing a conflict or escalating it.
- -United States and United Kingdom strategic nuclear forces which provide the ultimate deterrent.

In the event of the use of non-nuclear unconventional weapons, the Alliance is firm in its response, that being a rapid and convincing retaliation to demonstrate the futility of the pursuit of that form of battle.

DIVISION OF NATO.

NATO is divided into two sides, a military and a civilian side. Within the military organization, there are agencies and boards which address specific areas. The NBCOIWP is chartered under the MAS and within responsibility of the Army Board. The NBCOIWP reports to the Army Board which has charter for all NBC matters for all Services.

ORGANIZATION AND OPERATIONS OF NBCOIWP

The NBCOIWP is an interservice organization which represents naval, land, air and, when appropriate by nation, amphibious forces. All NATO nations are represented as well as all major land and sea commands. The NBCOIWP exclusively exists to coordinate NBC operation issues within the Alliance. This also includes limited technical issues consideration.

This Working Party also recommends through appropriate channels areas for future consideration at different levels within NATO.

U.S. ORGANIZATION AND OPERATION WITHIN THE NBCOIWP.

The U.S. participation in the NBCOIWP is through the DOD Action Agent. U.S. representation includes Points of Contact from Chief of Naval Operations, Headquarters, U.S. Marine Corps, U.S. Army and U.S. Air Force. The points of contact coordinate, staff, and review Service positions to documents, policies and programs within each Service as well as participate in U.S. position discussions to consolidate all Service positions with or without specific reservations. The DOD Action Agent staffs the consolidated Service positions within the Joint Staff and Department of Defense (DOD). Upon approval of the Joint Staff and DOD, the consolidated Service position becomes a U.S. position which the U.S. delegation presents to the NBCOIWP at the yearly meeting.

AGREEMENTS UNDER NBCOIWP CONTROL

At present, the NBCOIWP administers a total of 22 STANAGs; 15 are promulgated, 2 are drafts and 5 are proposed. The U.S. is the custodian of 8 STANAGs. The U.S. and U.K. are developing a new section of STANAG 2917 to address decrements as a result of wear of Individual Protection Equipment (IPE) in an NBC combat environment. It is anticipated this may result in the development of two new STANAGs.

The NBCOIWP is responsible for the following Standardization Agreements (STANAGS):

No.	Title	Custodian
2002	Warning Signs for Making of Contaminated Land Areas, Equipment and Supplies	NL
2047	Emergency Alarm of Hazard or Attack	NL
2083	Commanders Guide on Nuclear Radiation Exposure of Groups	US
2103	(ATP45) Report of NBC Attacks and Predicting and Warning of Associated Hazards	DA
2104	Friendly Nuclear Strike Warning	US
2111	Target Analysis-Nuclear Weapons	US
2112	Radiological Survey	US
2133	Vulnerability Assessment of Chemical and Biological Hazards	US'

2150	NATO Standards of Proficiency for NBC Defence	GE
2225	Technical Data for Handling Custodial Nuclear Weapons	US
2352	NBC Defense Equipment Operational Guidelines	NL
2353	Evaluation of NBC Defense Capabilities	FR
2941	Guidelines for Air and Ground Personnel Using Collective Protection Structures on Permanent Air Force Installations	UK
2957	Systems International (SI) Unit for Combat Dosimetry	BE
2984	Graduated Levels of NBC Threat and Minimum Individual Protection	UK

Drafts.

2917	(AXP-7) Chemical Casualty Assessment	NE(S)
2367	(AAP-21) Glossary of NBC Specialist Terminology	UK

Proposals

2378	NBC Protection Measures for Commodities Within Supply Channels	US
2398	Friendly Chemical Attack Warning	US
2910	(AXP-6) Nuclear Casualty and Damage Assessment	NS(S)
2974	Decontamination of Personnel and Equipment in an NBC Environment	GE
5624	NBC Requirements for ADH	DA

All STANAGs are reviewed at least once every 24 months. Between yearly meetings several ad hoc meetings occur to discuss technical information for current or proposed STANAGs.

FUTURE EFFORTS OF THE NBCOIWP

Future efforts of the NBCOIWP include topics as follows:

1. Total prevention or reduction to insignificant levels of transfer of NBC contamination into clear, collective protective protected enclosures and vehicle interiors (entry-exit-procedures).

2. Decontamination of vessel, vehicle, aircraft or shelter with or without collective protection.

3. First aid, medical triage, treatment, decontamination and evacuation of patients exposed to the effects of NBC weapons or agents or the combined effects of NBC and conventional weapons.

4. "Administration" of dry pretreatment and treatment regimens to reduce or eliminate the hazards from exposure to radiation or CB agents.

5. Employment of collective protective systems - vessels, vehicles, aircraft and fixed facilities used by combat, combat support and combat service support operations.

6. Partial and complete decontamination of interior and exterior surface of vessels, vehicles, aircraft and equipment, i.e. objectives, priorities and means.

7. Continuous operations in a contaminated environment, i.e., all training centers examine their various missions in the possibility of operating in the NBC environment, and determine whether or not a change in operational procedures may be required in order to fight in a contaminated environment.

8. Decontamination of non-vehicular material with special attention to electronic, optical, porous and nondurable equipment.

9. Doctrine for masking, unmasking and exchange for contaminated protective uniforms once a detection and warning system alerts the commander that a CB attack has occurred.

10. Disposition of contaminated stocks, i.e., abandoned, destroyed, stored or issued in a contaminated condition.

11. Procedures for drinking, nourishing, ventilating and providing for individual bodily functions in a contaminated environment when a collective protection facility or clear area is not available.

12. Processing and identification of samples of unidentified CB warfare agents to include toxins and of unidentified composition of ground radioactivity.

13. Reporting system which simplifies and expedites the transfer of NBC strike warning, contamination data, post strike analysis and NBC defence guidance.

14. Measures to reduce impact of the NBC environment on civilian military cooperation (CIMIC) problems.

15. Policy and doctrine on handling, decontaminating and transporting contaminated remains.

16. Policy and doctrine on the responsibilities and procedures for emplacement and maintenance of NBC hazard matters.

17. NBC recce measures at the different command levels.

18. Policy, procedures and equipment for recording exposure to radiation.

19. Measures to include chemical hardening at the design stage of new equipment and vessels.

20. Policy and procedures to give priority to the removal of chemical contamination.

BIOGRAPH FOR MAJOR ROBERT J. KAINZ, SCD

Education:

Bachelor of Science, Industrial Technology
Eastern Michigan University 1970

Master of Public Health, Environmental Health
Tulane University 1977

Doctor of Science, Occupational Toxicology
Tulane University 1981

Graduate of Command and General Staff College

Honors

Congressional Fellow 1982-1983
Congressional Advisor 1983-Current
Consultant to Science Advisor Executive Office of the President 1983-1984
Science Director Agent Orange Litigation Department of Justice 1983-1984
Advisor National Science Teachers for the High School Shuttle Project Program
Member of Colloquim to UK Parliament
Member Delta Omega Honor Society

Service in Vietnam, Germany and CONUS
Twenty-two months command experience in the field, has served at the laboratory and major command level in R&D.
Been assigned to DA field activity for DCSOPS.
Presently DOD Action Agent NBCOIWP NATO.

Seventeen years service.
Selected for promotion to Lieutentant Colonel

Published over 50 science/policy articles in scientific and military publications.

Author for legislative findings for the U.S. Congress.

Prepared two Congressional Positions for U.S.

AVIONICS DECON FROM USAF/NATO CONFERENCE

CAPTAIN CANDACE TOMLINSON

Chemical Defense Divsion
Life Support System Program Office

The requirement we are working to meet for the Avionics Decontamination program is to develop a system that will decontaminate avionics without degrading any of their operational capabilities or service life. Operationally, decontamination of avionics equipment will allow:

a) Avionics equipment to enter a collectively-protected maintenance facility for repair or calibration. HQ USAFE has several hardened, collectively-protected maintenance facilities and is currently constructing more.

b) Reduction of MOPP gear worn by personnel in noncollectively-protected maintenance facilities because the liquid hazard from avionics equipment shall be removed.

c) Safe transport of avionics equipment to uncontaminated bases and depots.

I would like to provide you with a little background on the program and how the interest/requirement for avionics decontamination evolved. USAFE has constructed several hardened, collectively-protected avionics maintenance facilities in the past and is in the process of constructing more. In order to utilize the full capabilities of these hardened facilities, there must be an effective, efficient decontamination method/system to allow the avionics equipment that enters the facility to be decontaminated. Also, the Army had been interested in developing a non-aqueous decon system to help alleviate the logistics difficulties caused by an aqueous-based decon system and to allow decon of items that could not be deconned with an aqueous-based decon method. The Air Force and the Army became aware of a Freon 113-based system that was used for nuclear decon in the nuclear industry. The Army (CRDEC) then procured one of the freon nuclear decon units and had it modified to provide for chem/bio decon capabilities also. They conducted live agent testing on the unit. The testing was successful, and the Army decided to pursue the development of a militarized version of this unit.

Our current Avionics Decontamination program consists of two "sub-programs": the glovebox system (XM-19) and the chamber system. The XM-19 is a joint program with the Army (Army lead). The XM-19 is designed to decon "normal-size" avionics or typical black boxes that are removed from aircraft. The Army has a Proof-of-Principle/Full Scale Development contract for the XM-19 design, fabrication, and test. The chamber system is designed to decon large, outsize avionics equipment such as ECM pods etc. The program is just entering Full Scale Development. This is a joint program with HQ USAFE with HQ USAFE acting as the program manager and ASD providing technical/consulting advice.

The XM-19 is a Freon 113-based system. The Freon 113 acts as a removal medium for the live agents when it is sprayed (as a liquid) on the equipment. The freon is then collected, and through a distillation and neutralization process, the live agent is removed and neutralized and the freon is recycled for reuse. The XM-19 must be compatible with a detection system to allow decon verification before the avionics equipment is removed from the XM-19 into a TSA. The XM-19 must also be compatible with avionics/electronics maintenance facilities where it will be installed.

The chamber system uses the same technology as the glovebox system and will have a similar subsystem. The main difference is that the large chamber is required to accomodate the large avionics equipment, and the operator life support sytem is required for personnel who will be inside the chamber performing the decon actions.

The XM-19 has completed the design phase and is in prototype fabrication. Additional live agent testing is underway at Dugway Proving Grounds. DT/OT is scheduled for Mar - Dec 88 with FUE/IOC scheduled for 3rd Qtr FY91.

As previously mentioned, the chamber system program is a joint effort with USAFE. We plan to get the USAFE effort started and have a follow-on effort for PACAF/MAC units after their operational requirements and concepts have been finalized. The contract start-of-work for the USAFE prototype contract is expected in Oct 87.

'JS ARMY DECONTAMINATION PROGRAM - AN OVERVIEW

DR. James A. Baker

The Army has very recently completed a Master Planning Process in the Decon program. As a result of that plan the program has been restructured from top to bottom. This paper discusses that plan and the resulting program.

The process was divided into two Phases. The Army's requirements only were addressed first in Phase I. The results of that study are complete and the process of incorporating Joint Service needs into those results has begun. The entire process begins with a User's meeting. At that meeting the actual users of decontamination hardware were asked for their requirements for decontamination. They were asked to answer a series of questions and provide their insights, unconstrained by their perceptions of what the development community could provide. This User's meeting was attended by Captain and Major level officers from the US Army Training and Doctrine Command Headquarters and twelve of the individual service schools.

At the meeting the representatives were divided into three working groups: Combat, Combat Support and Combat Service Support depending on the particular mission responsiblity of the Branch they represented. In theses working groups the officers were asked to consider a set of three scenarios representing different CW situations that might be faced by a representative unit, and then to describe the decontamination requirements dictated by that particular scenario. Of particular importance to Air Force or air base operations are the answers and opinions obtained from the Combat Service Support Group.

Representatives were asked to list the materials or surfaces they felt required decontamination. This produced a rather comprehensive list of surfaces. More important than the specific items on the list is the fact that the list is long and comprehensive. At one point nearly anything present on the battlefield will require decontamination. Next the users were asked to summarize their discussions by naming the important characteristics of the required decontamination systems and of the required decontaminants. This produced two lists: Minimal Acceptable Characteristics and Optimal Characteristics. Again, for present purposes, the importance of these lists is not the specifics of what is on the list, but the extent of the issues addressed.

There were no real surprises in either of these lists; as expected they called for what fundamentaly would be magic. There is a gradation in evidence, however, in several cases. For example, "Effective against all persistent agents" was given as required; "Effective against <u>all</u> agents" is desired. These criteria were then used to evaluate the potential of a series of different methods of doing decontamination. The users, using threat information and battlefield situations provided, and a list of surfaces requiring decontamination that they generated, produced a list of Decon Needs.

Those criteria were then recast into a set of 35 measurable performance characteristics. Those 35 characteristics were then assigned, with the help of the Chemical School, relative worth values representing how important the satisfaction of that criterion was to the Combat, Combat Support, and Combat Service Support Units. Next a list of the technologies to be evaluated using these measureable performance criteria was prepared. This list included nearly every method of decontamination ever proposed.

A technology review sheet for each technology to be evaluated was then created. On that sheet all 35 criteria were given, with 4 levels of satisfaction of each criterion, representing the levels of "Desired Performance", "Good Performance", "Minimally Acceptable Performance", and "Fails to Meet Requirements". In some cases these levels were subjective in nature. For example, in some cases only the levels "Demonstrated", "Probable", "Possible" and "Not Possible" corresponding to the desired, good, minimal, and failure levels were given. In other cases it was possible to quantify the requirements. For example, Storage stability; indefinite was desired, 10 years was good, 5 years was minimal, and 1 year or less a failure.

Twenty-five judges were chosen from CRDEC; Battelle Columbus Laboratories; and the staffs of two CRDEC University Technical Centers, University of Florida and University of Pittsburg. Not all judges were asked to rate all technologies, however. Judges were asked to evaluate technologies within their specific areas of expertise.

Following the return of the evaluations by the judges, the point value for the level of satisfaction of each criterion was multiplied by the relative worth of that criterion for each of the three units, and the "scores" totaled. Technologies were considered singly and two at a time. This was done since in some combinations it was possible that a failure for one technology against one criterion could be "covered" by the companion technology allowing somewhat, for synergism. The statistical staff of the Ballistics Research Laboratory at Aberdeen and the CREDEC Studies and Analysis Office analyzed the results. They looked for bias of the judges and for unexplainable trends in the scores. Results indicated that generally the judges were very objective.

Not surprisingly it was concluded that no single technology would solve all problems. Trends in the top ranking technologies were found, however and a program has been developed based on those trends which will go a long way to satisfy the users' needs. That program is step-wise and suggests fielding interim solutions, for each type of decontamination, which can be improved through more research and development.

One type of decontamination is decontamination done by the individual soldier himself, without any help. He's all on his own, and he does this kind of decontamination to limit the spread of the contamination and to limit problems later. In current Army doctrine this is termed "Basic Soldier Skills" decontamination. The next type of decontamination is the decontamination that a small unit does for itself. In this type of decontamination larger pieces of equipment common to the whole unit are decontaminated in order that the unit can continue its mission. It is also hoped that, by decontaminating some now, the time required for the remainder of the contamination to disappear naturally, will be reduced; so that the protective posture can be reduced sooner. The name for this type of decontamination in current doctrine is "Hasty " decontamination.

Finally, at some point it may be necessary to clean up completely. At this point the contaminated unit seeks the help of specialists who are trained to do a thorough and exhaustive decontamination, the Chemical company. When this process is done the MOPP level can be reduced substantially with minimum risk. The name for this type of decontamination in current doctrine is "Deliberate" decontamination.

Regardless of the names attached, however, the basic objectives and operational limitations of these basic types of decontamination remain and are common to operations on an integrated battlefield. The program proposed for these types of decontamination is:

1. The development of a sorbent decontamination system for use by the individual soldier. Sorbents are easy to use, broad spectrum decontaminants for liquid agents and offer advantages if the problems of off-gassing and limited capacity can be solved. The interim solution sorbent will offer sorption of all the liquid chemical agents and subsequent destruction of some. The improved sorbent will offer catalytic destruction, thereby introducing the potential for reuse capability.

2. The development of a coating system for use by the individual unit. Aa coating system can be developed which offers higher levels of decontamination efficacy than the current standards, for equal or only slightly greater logistic costs. The interim coating will be applied <u>after</u> contamination and will then be removed, by any of a number of mechanisms, taking the contamination with it. The far term capability in this area will be a more permanent coating incorporating catalytic chemistry which will destroy liquid chemical agents deposited on it.

3. For use by the Chemical Company to perform complete clean-up operations, the development of an emulsion based decontaminant. This decontaminant will replace our current standards DS2 and STB with a less corrosive catalytic material that can be easily mixed in the field. The first capability, represented by the Multipurpose Chemical/Biological Decontaminant, will decontaminate all agents, some catalytically, some stoichiometrically, and some via physical removal. The improvement to that system planned will incorporate totally catalytic chemistry.

The steps in the implementation of the Master Plan, then, are these: Start work on a sorbent, pick from one of the known coating systems, and continue ongoing work on emulsions. Finally, expand to Joint Service needs. Progress has been made in that area as well. The Joint Service Users' Meeting was held in May, and copies of the report of the discussions at that meeting have been mailed to meeting participants, and others, for comments. Development of a strategy for integrating the earlier Army effort with the new Joint Service requirements has begun. Publication of the Plan is scheduled for next Spring.

That concludes the major points from the plan for the early stages of development. The Plan also includes continued development of the Non-Aqueous Decontamination System and the Improved Sanator System, subjects which will be discussed in other presentations. CRDEC also intends to recommend fielding the German C8 emulsion decontaminant, which will not be discussed here. This material, based upon the German work, will be used at the Equipment Decontamination Stations instead of DS2 and STB until such time as the microemulsion system is fully fielded there.

A PORTABLE CONTAMINATION MONITORING UNIT

by Maj. Gen. (Ret.) Pierre G. RICAUD

Member of the French Defense Science Board

Contamination control requests preliminary identification of contaminated areas of ground, aircrafts, vehicles and equipments, and subsequent testing of the efficiency of decontamination operations. It is particularly important for the Air Forces whose very corrosion-sensitive materiel demands soft decontamination processes, needing for this reason very carefully and precise monitoring.

For this purpose, Centre d'Etudes du Bouchet and PROENGIN Co develop jointly a Portable Contamination Monitoring Unit (AP2C), detecting vapors of nerve agents as organophosphorous compounds and of mustards as sulfureous compounds. The developpers chose flame photometry for this monitoring because of its peculiar advantages tested from many years in chemical alarm detection with the French local detector DETALAC (1). These advantages are :

- a great sensitivity
- a quick response time
- a very short hysteresis
- an insensitivity to atmospheric humidity and to most interfering substances
- a good ageing as well during storage as in operation

The analysis is based on spectral lines emitted with the maximum light intensity, in a reducing environment due to an excess of hydrogen by-radical.

POH	i.e.	525 nanometers
S_2		394

DESCRIPTION OF THE MONITOR (Fig.1)

AP2C is made up of:

- a circulator sucking air in
- a burner in which the sucked air feeds an hydrogen flame

(1) Manufactured by GIAT

- an optical system with filters selecting spectral lines at useful wavelength
- a photosensor sensitive to the selected spectral lines
- an amplifier of the photosensor signals
- an electronic data processing of amplified signals
- a display indicating values of the two types of toxics
- an hydrogen supply device
- a reducing valve and a flow regulator
- an electric supply
- a control knob

The circulator (Fig.2) is specially designed for a constant rotation speed of the impeller, independently of the condensation from the burner, or ice forming at low temperature.

The hydrogen burner is miniaturized, reducing hydrogen need to 1.8 liter/hour. The sucked external air is shared in two streams : one, inside the central tube of the burner in the direction of the optical axis, mixes with hydrogen to feed the flame. The other part flows peripherally and sweeps the burnt gases from the optical system window, avoiding its corrosion and steam condensation.

A high tension spark plug inflames the mixed gases : the spark is initiated when the extinguished burner emits no longer the UV ray corresponding to HO-radical (wavelength 310 nm).

The optical system includes a rotating disk (Fig.3) with 5 interferential filters : in order to avoid interferences from compounds eventually emitting at a wavelength close to the toxic, but with a wider spectrum, a second filter is associated to each of the two filters centered on the spectral line of the toxic. The wavelengths of these secondary filters are some nm apart from the main ones, corresponding to the bottom of POH and S2 spectral lines. The signals from these radicals are the differences between the main and the secondary signals. The fifth filter is an U.V. one for detecting the burner quench.

An optical encoder sends a signal each time a filter is centered on the beam.

From each side of the rotating disk, fixed lenses respectively collimate and focalise the beam.

The hydrogen supply. Hydrogen is adsorbed on lanthanium-nickel alloy, at low pressure (atmosphere pressure at 15°C,-15 bars, the maximum pressure,at 75°C).

The alloy fills up a removable stainless steel container, located in the AP2C handle, and ejected for replacement and refilling by actuating the on-off button (Fig.4). At low temperature, a resistor inside the handle heats the cylinder to get an hydrogen flow. A valve reduces the pressure down to 200 millibars, then a regulator restricts the flow-rate to 1.8 liter/minute. A sensor in the reducing valve checks the upstream hydrogen pressure and controls electrical heating of the storage alloy.

So the hydrogen flow is regulated at ± 2 % along the whole range of operating temperatures.

The display (Fig.5) gives information about :

- the apparatus state (hydrogen and power supply, circulator and heater state...)
- the toxic concentration

The two concentrations are simultaneously displayed in micrograms / cubic meter of P or S, either in the digits or bargraphs. A sound signal, with a frequency proportional to the toxic concentration, may be received in an earphone, connectable through an external plug (Fig.5).

Electric supply

The AP2C is powered, under 6 V, by two lithium-chloride batteries. It may be connected, through a second plug, to a 24 V external supply.

PERFORMANCES

Sensitivity :

1 $\mu g/m^3$ total phosphorus i.e. 5 $\mu g/m^3$ GB or GD
10 $\mu g/m^3$ VX

25 $\mu g/m^3$ total sulphur i.e. 125 $\mu g/m^3$ HD

Response time :

less than 1 sec. for 1 $\mu g/m3$ phosphorus

Hysteresis

Ultrafast return to nominal sensitivity, even after detection of high concentration of low volatil toxics : less than 1 minute after checking of a vehicle highly contaminated by GD (10 mg/m^2), AP2C can detect 10 $\mu g/m^3$ of GD. This fast return is permitted by absence of any barrier for toxic from outside to the hydrogen flame, and by the heating of the sucking tube by the flame.

These characteristics (sensitivity, response time and non-hysteresis) allow to scan a contaminated area displacing AP2C at a speed of 1 foot/second.

Interferences

Very few compounds interfer, if they do not contain P or S. Placed in the smoke of a fire burning 20 or 30 meters away, AP2C gives no false indications with fires of wood, painting, petrol or drain oil. Tyre fires give response to sulfur.

Among obscurant smokes, only the white one gives a false response due to hexachlorethane.

Vehicles exhaust gases, petrol or diesel vapors do not interfer.

No response with ethyl alcohol.

The chlorinated products (namely the decontaminants) do not interfer.

Quick operability

Measurements may begin 10 seconds after starting (1 minute at normal temperature if replacing the hydrogen cylinder and 3 minutes at cold temperature -20°C, due to the need of purging the hydrogen circuit. The replacement of the cylinder itself is instantaneous.)

Reliability

No changes of characteristics and no maintenance or recalibration after a long time of use or storage.

AP2C is unsensitive to atmospheric humidity, and, even if its nose is immersed, it cannot suck in liquids because of the small depressure (2mb) given by the circulator.

Temperature range

For operations - 10°C + 50°C

For storage - 40°C + 75°C

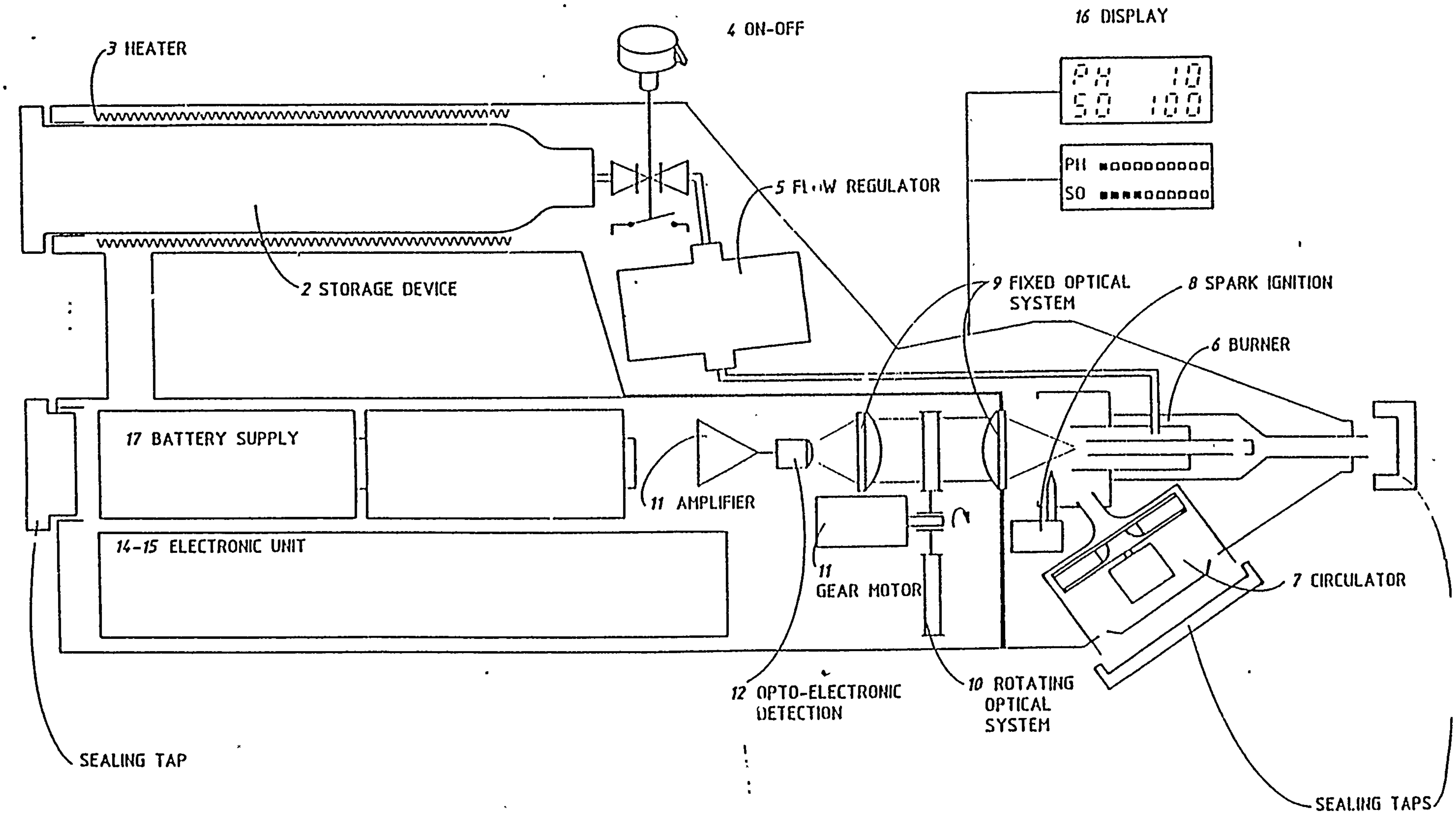
Operating time range

12 hours non stop working, even at low temperatures which need more power for heating the hydrogen storage device.

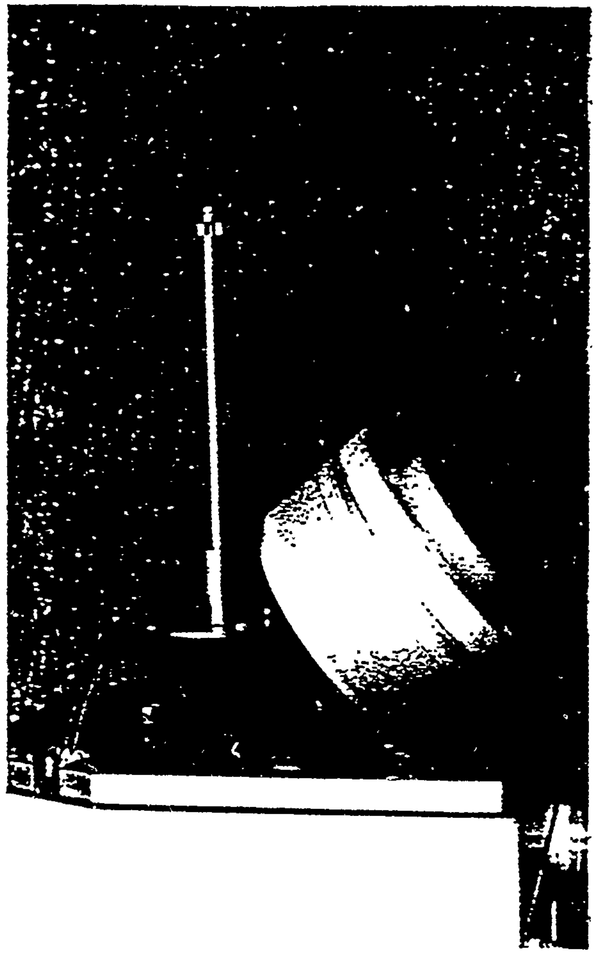
Size and weight (approx.)

13.5 x 5.5 x 4.5 inches - 5 pounds

So, flame photometry appears as an efficient way for monitoring CW agents, and AP2C a promising apparatus for this purpose.

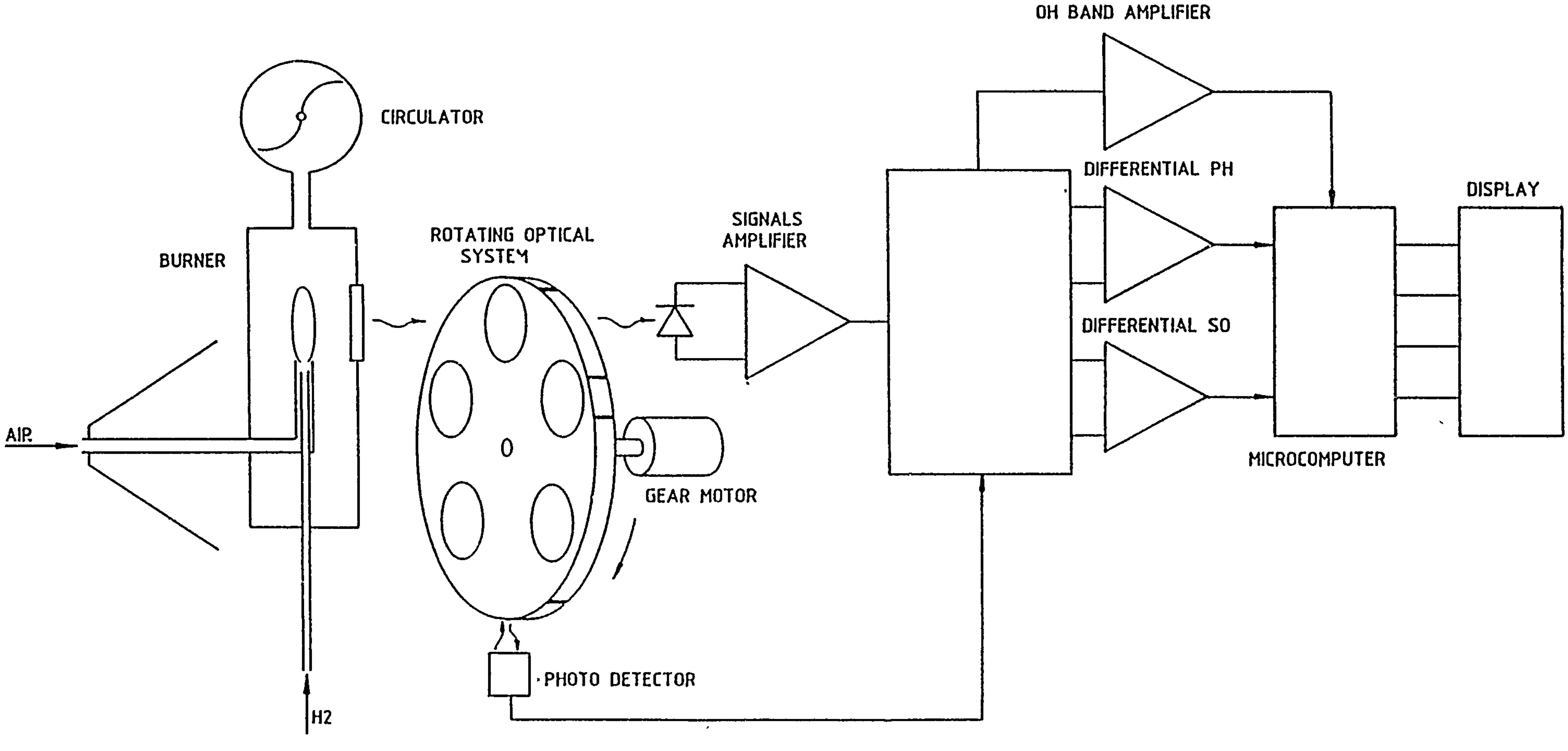


AP2C : GENERAL DIAGRAM

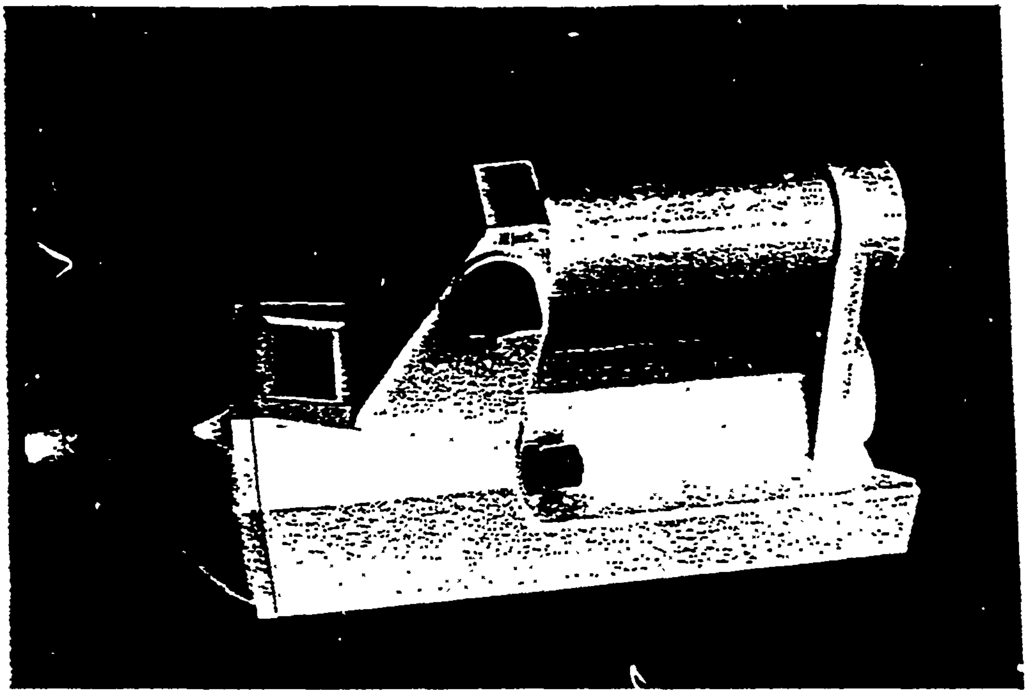


AP2C : CIRCULATOR

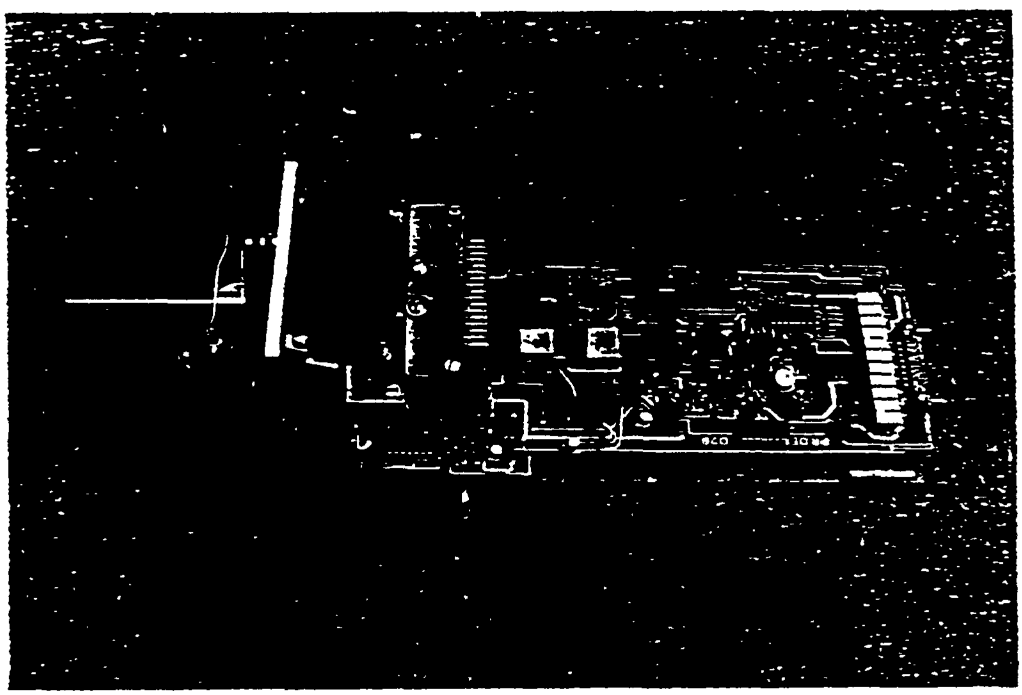
Fig 2



OPTICAL & ELECTRONIC UNIT

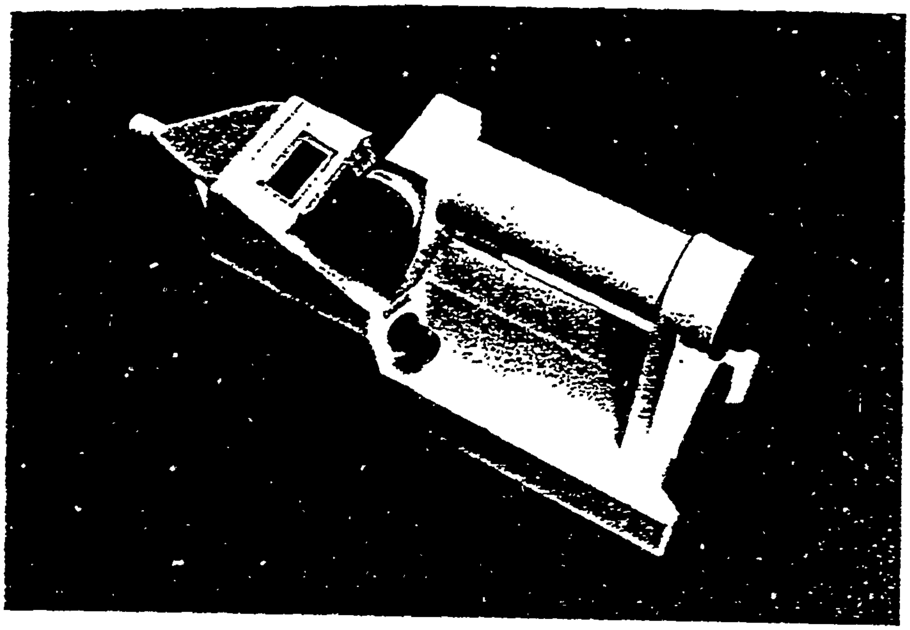


AP2C : OUTSIDE VIEW



AP2C : INSIDE VIEW

Fig 4



AP2C : OUTSIDE VIEW

NBC SANATOR - NEW DEVELOPMENTS

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I. INTRODUCTION

The NBC Sanator is an apparatus used to generate and deliver hot water or steam used for Nuclear, Biological, and Chemical (NBC) decontamination operations or for personnel showers. The item is lightweight and portable, and can pump water from any source. The system is powered by a 7.3 horsepower, two-cycle gasoline engine. The system's burner can accomodate any of a wide variety of fuels ranging from diesel fuel to gasoline and jet fuel. The original NBC Sanator was designed and manufactured in Norway. Major components of the system include a 1500 gallon, rubberized fabric, collapsible water tank, the water pumping and heating unit, and an accessory kit which contains hoses, spray wands, and shower hardware.

II. REQUIREMENTS FOR A LIGHTWEIGHT DECONTAMINATION SYSTEM

The Army's requirements for the Lightweight Decontamination System (LDS) specify that the system must:

1) Possess three components at most, each of a weight no more than 400 pounds,

2) Pump water from 30 feet away horizontally and 9 feet vertically,

3) Possess a personnel shower capability for 10 individuals,

4) Possess two, easily maneuverable wash wands,

5) Possess the capability to inject detergents,

6) Be operable in hot and basic climates,

7) Be safe and operable by personnel in NBC protective ensemble,

8) Be capable of set up in less than 30 minutes,

9) Possess a reliability of 150 hours mean time between failures.

III. EARLY TESTS OF THE NBC SANATOR

The Chemical Research, Development and Engineering Center (CRDEC) along with the 82nd Airborne Division and the U.S. Army Foreign Science and Technology Center (FSTC), conducted preliminary tests of the original Norwegian NBC Sanator beginning in 1978 and found that the system had the ability to provide hot water or steam on the integrated battlefield for "hasty" decontamination at the battalion level.

In accordance with current U.S. Army doctrine contained in Army Field Manual FM 3-5, NBC Decontamination, "hasty" decontamination is done to remove gross contamination to help accelerate the natural weathering process. "Hasty" decontamination is not meant to be complete, but it will allow for a reduction in protective posture sooner than would be possible if just natural weathering was to occur. Up to this point, the Army lacked the ability to perform "hasty" decontamination at the battalion level in light divisions.

After these initial tests of the original Norwegian-built item, a U.S. manufacturer, Engineered Air Systems, Inc. (EASI) of St. Louis, Missouri, acquired an exclusive license from the Norwegian inventor to manufacture the system and began to build the item in the U.S. This U.S. system was then formally tested by the Army and the Air Force. Through these tests it was noticed that the system had field deficiencies, namely cold weather operability, potential safety problems, and lower than desired reliability. The Air Force, who, along with the Army, had an urgent requirement for a LDS, adopted it and designated it the A/E32U-8 decontaminating apparatus.

Because of its urgent need for a LDS, the Army followed suit and also adopted the system on a limited basis in 1984 and procured a small quantity of items. Beginning in 1986, the item was fielded to select Army units in Germany, Korea and the U.S. to satisfy this urgent requirement.

IV. IMPROVEMENTS TO THE A/E32U-8

The A/E32U-8's reliability, cold weather operability, and safety were not fully satisfactory for the Army. Several system improvements were needed before the Army was willing to fully adopt it. So, beginning last year, with guidance from the Army in noting the problem areas, EASI made changes to enhance the system's performance. The changes include:

1) A relocated, redesigned, more automated control panel which provides for better and easier operator visibility and control;

2) Different hose couplings, which are similar to those of the M12A1 decontaminating apparatus, which allow easier connection during winter operations;

3) Trigger-actuated, "car wash" style spray wands to provide better operator control and to conserve water;

4) Redesigned burner fuel control and water flow systems which allow for more automated operation;

5) And, a fuel can bracket which locates the engine fuel farther away from the engine.

This modified version NBC Sanator became known as the XM17E1.

V. TESTING OF THE XM17E1

Once the design changes were made, EASI manufactured, and CRDEC acquired several systems for test. The items were then tested at an Operational Test (OT) with the 82nd Airborne Division at Ft. Bragg, North Carolina during August and September, 1986, and at Development Test (DT) at the Tropic Test Center in Panama and at Dugway Proving Ground, Utah from November 1986 through April 1987.

All test activities found that this version was much improved, that earlier problems were alleviated, and that the Army's requirements for a LDS were fully satisfied. In May 1987, with these test results, the Army type classified this improved version NBC Sanator as standard, renaming it as the M17 Decontaminating Apparatus.

VI. PROCUREMENT AND FIFLDING OF THE M17

With the system type classified as standard, actions to procure the item for fielding are underway. In September 1987, the initial, production contract for the first 1000 systems is scheduled to be awarded on a noncompetitive basis to the U.S. licensee. Delivery of production items is scheduled to begin in late 1988. The Marine Corps is also procuring systems through the Army.

Fielding to Army units is scheduled to begin in 1990 and is planned to be complete by 1995.

Preceding and concurrent with the operational and development tests, negotiations were also being conducted between the U.S. Government, the Norwegian inventor, Karl Hoie, and the sole U.S. licensee, EASI to acquire the technical data to allow the U.S. Government to competitively procure the system. In July of this year, negotiations were completed and an agreement was reached. As a result of the agreement, competitive procurement of the system will be possible after the initial procurement, at which time the U.S. Government will acquire the technical data for the system.

VII. FUTURE PLANS

At present, CRDEC is evaluating a new, 3000-gallon, self-supporting, rubberized-fabric water tank, known as the "Onion Tank," to determine if it is an acceptable replacement for the current 1500-gallon M17 water tank. The "Onion Tank" was developed by the U.S. Army Belvoir Research, Development and Engineering Center and was recently type classified by the Army. The "Onion Tank" will be fielded with water purification units. Inclusion of the "Onion Tank" into the M17 Sanator's configuration would be a step toward standardizing water tanks within the Army.

Aside from evaluating the "Onion Tank," CRDEC will also be conducting a study to determine the feasibility of retrofitting the old A/E32U-8 systems to upgrade to the M17 configuration.

Additionally, beginning next year, CRDEC plans to investigate the feasibility of replacing the current two-cycle gasoline engine with a diesel engine. A diesel engine-powered system is preferred in order to reduce the logistical burden associated with the resupply of two-cycle oil, and to make the system comply with recent Army guidance specifying use of diesel or JP-8 only in all engines by the year 2000.

Finally, in fiscal year 1989, CRDEC plans to begin competitive procurement of the remaining Army requirements, using the technical data obtained by the license agreement.

Chemical Warfare/Chemical-Biological Defense

Information Analysis Center

MR. STEPHEN LAWHORNE

The Chemical Warfare/Chemical-Biological Defense Information Analysis Center, referred to as CBIAC, was established by the Department of Defense as a focal point for information and analysis on all aspects of chemical agents and matters pertaining to them. The IAC is operated by Battelle Memorial Institute on a contract through the Defense Logistics Agency's Defense Electonics Supply Center in Dayton, OH. Our IAC is one of several serving the Department of Defense under a program that originated in 1946. All of the IAC's are similar in operation, but vary in the subject matter they cover. Each center collects, reviews, analyzes, appraises, summarizes, and stores internationally available information on their own particular subject areas. The collections, which are computerized, are expanded on a continuing basis to incorporate the most current international research information. The synthesized information is then repackaged and disseminated according to expressed or anticipated needs. The services of the IAC are available to the entire Department of Defense, other government agencies, U.S. Government contractors and grantees, and the private sector to the extent practicable without impairing the services to DoD and consistent with security or other limitations on release of data.

The basic mission of the IAC is to collect, appraise and distribute information on chemical research. The types of service available from the IAC, which involve ways the basic information is disseminated, include:

Abstracts and Indexes - Announcements in the form of abstracts and indexes of pertinent reports and publications in the chemical arena. The abstracts would include a summary of the report being abstracted and an analysis of the work, such as any limitations encountered in the testing, etc.

Technical Inquiries - Authoritative advice in response to technical questions posed by the user. We place a great emphasis on the "analysis" aspects of the center. The authoritative advice comes as a result of proven performance and established expertise in the field. It is supported by the information gathered and evaluated from the entire chemical community.

Bibliographic Inquiries - References to the latest and most relevant authoritative reports covering the user's inquiry. The IAC will scan the available information to separate those reports dealing directly with your question from those that are only peripherally involved, allowing you to make the most efficient use of your time and efforts.

Reference Works - Useful and authoritative information applicable to on-going work through design, preparation, and maintenance of handbooks and data books. We will generate at least one handbook in the next three years.

State-of-the-Art Reports - Summaries of the status of technologies that are pertinent to current research, development, test and evaluation (RDT&E) decision making with usefulness extending from the bench level to all levels of management. Two such reports will be generated each year of the contract.

Critical Reviews and Technology Assessments - The latest scientific or engineering information in the most useful format on subjects of significant interest to the defense RDT&E community. These reviews and assessments may provide comparative analyses of technologies based upon technical, national, and/or geographic considerations.

Current Awareness - Newsletters and reviews to keep the Center's users appraised of the latest and most significant technological development within the chemical arena. This will also be the forum used to announce new capabilities and efforts within the IAC itself.

Special Tasks/Studies - Detailed problem solution information which is narrow in scope. These tasks are usually beyond the rather simple scope of the above services in that they require significant expenditures of time and labor which are specific to the user's requirements, and therefore, require direct funding by the user. These tasks may range from simple studies to planning and conducting international conferences. The scope of work for the special tasks and studies must be within the scope of the IAC, and the results of the study, whether it be a report or other type of product, must also be available for use by the IAC.

There are several differences between the IAC and a technical library. First, the IAC produces specialized products, such as State-of-the-Art Reports and Handbooks. Perhaps most importantly, the IAC will handle information and data directly, whereas a library normally handles books and reports that contain that information. And finally, the IAC has the personnel and expertise to apply that information directly to your problems or research areas. The IAC can analyze and interpret that information to determine what the impact on your application might be.

The IAC basic contract was awarded for three years, with two option years available at the Government's discretion. The basic funding consists of $500K per year for the "core" functions of gathering information, answering technical inquiries, and preparing SOAR's and Handbooks. The contracting officer for the IAC is located at the Defense Electronic Supply Center (DESC), Dayton, OH. The Defense Technical Information Center (DTIC) has administrative oversight over all IAC's to coordinate and control the updates and access to their Defense Research On-Line System (DROLS). The Defense Logistics Agency, the parent organization of both DESC and DTIC, is responsible for the basic funding of the IAC.

The IAC is physically located at CRDEC. The functions of gathering, evaluating, collating, and storing information are performed there by a dedicated staff. For the special tasks and studies, the IAC can draw on the corporate resources of Battelle or they may subcontract the work. The special tasks will not dilute the information gathering by diverting the efforts of the dedicated IAC staff.

The IAC can distribute its products to industry as well as government. The special reference works, state-of-the-art reports, etc. are available for sale to industry, consistent with any other restrictions on the information, such as classification. Obviously, as a new effort, the IAC has not yet completed any such publications, but this is a capability that you should be aware of; it is rather unique. You do not have to be under a current contract to obtain all of these materials.

The IAC interfaces with the Defense Technical Information Center (DTIC), other IAC's, and the National Technical Information Service. In other words, they provide one-stop shopping. Using the IAC will relieve you of the burden of checking with a number of agencies to be certain that you have all of the information you need. By a like token, the IAC's formal products will be available through these other services.

The IAC is cleared through the Defense Investigative Service to handle classified information. The IAC is also prepared to handle sensitive and proprietary information without compromise to the owner, but consistent with its mission of serving the DoD. It is important to note that the information holdings are the property of the government, and are handled accordingly.

To initiate a special task through the IAC is relatively simple. You must first identify the problem to be solved and prepare a scope of work. Once I have reviewed the scope of work and determined that it does indeed fall within the scope of work for the IAC, the IAC will prepare a proposal for you outlining exactly how they intend to perform the work you have requested. The proposal will include technical approach, schedules and cost. You will be asked to review that proposal to verify that all of your technical needs are addressed. You will then forward your funds for the work to the contracting officer at DESC by MIPR. When the contracting officer receives your funds and the technical concurrence on your task, a formal modification will be made to the contract to incorporate this special task.

The basic criteria for tasks that can be accepted by the IAC is that the task fall within the overall scope of the IAC contract. That means that the task must involve the gathering, analysis, or application of information pertaining to the chemical warfare/chemical-biological defense mission of the IAC. Each task is essentially a sole source contract, and the basis for the task assignment is that the unique expertise of the IAC - their familiarity with the subject area and their accumulated information resources - will allow the performance of your task more quickly and efficiently than any other path available to the Government. The task must address a specific, defineable problem and involve definitive deliverables. Level of effort tasks are not appropriate for the IAC. And the tasks are limited to the acquisition, analysis and application of information. Testing, fabrication, and procurement are not appropriate activities for the IAC.

One of the most important aspects of the IAC is the approach we are taking to data collection and storage. All IAC's are required by the regulation governing them to contribute to the input and upkeep of DTIC's data base system. But we have placed a further requirement on the CBIAC to create and maintain a user accessible data base dedicated solely to CBIAC affairs. We envision the data base including information required for DTIC, users, and the day to day operation of the IAC.

The data base will include abstracts and bibliographic information, similar to that presently contained in DTIC although there will be significant differences in the fields available for searching and the amount of information presented. We are also planning a bulletin board to announce upcoming meetings, conferences, symposia, etc. and electronic mail to facilitate communications with the IAC. In addition there will be files pointing to other data base systems maintained by other organizations which offer information pertinent to your needs, such as the AAMRL's data base on medical affects and MRICD's Chemical Agent Retrieval System (CARS). The IAC will maintain several data bases of numeric and textual information, such as the AF's materials data base and several data bases that are currently being developed under special tasks. There services are hoped to be offered to you via remote dial-up or MILNET connections. If you do not have access to either of these, certainly that same information can be provided you by telephone. The purpose of such a system is to offer you as much information in as easily accessible a manner as possible. Currently, the user accessible data base system is in the design phase with plans to have a prototype demonstration available some time in the near future.

Finally, I will leave with you a couple of names for any additional information. First, Mr. Fran Crimmins is the director of the IAC. His telephone number is (301) 676-9030. I would suggest that you normally speak first with Fran about the capabilities of the IAC, schedules, etc. As the COTR for the contract, I will by necessity be involved in the assigning of special studies and tasks to the contract, and one of my major roles will be assuring that these tasks are within the scope of the contract, technically, before formally recommending to the contracting officer that the task be assigned to the contract. Please feel free to call either of us.

You will find outside at the sign-in tables some information packages, including a one page flyer summarizing the IAC's capabilities and the procedures for getting more information. There are also a few copies of the IAC's first couple of newsletters. If you want to be included on the mailing list for the newsletter, give Fran your address.

Thank you.

DoD

Chemical Warfare/Chemical-Biological Defense

Information Analysis Center

Stephen Lawhorne
CRDEC
Data Mgt Office

IAC's

- Originated in 1946
- Similar in operation, dissimilar in subject matter
- Collect, review, analyze, appraise, and store information
- Incorporate most current international research
- Information disseminated as required

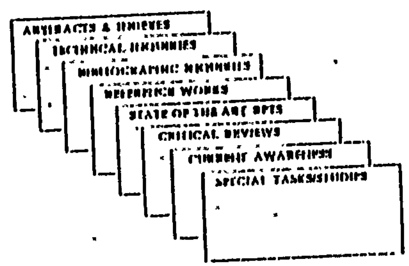
CB IAC

- 3 Year Basic Contract, 2 Option Years
- $500K per Year for "Core Functions"
- Defense Electronic Supply Center is Contracting Office
- Defense Technical Information Center is Administrator of IAC's
- Defense Logistics Agency provides funds

CBIAC

- Located at CRDEC
- Serves DoD and their contractors
- Interfaces with DTIC, other IAC's, HHS, and DoD Organizations
- Handles classified, sensitive, and proprietary information

IAC SERVICES



DIFFERENCES BETWEEN IAC AND LIBRARY

- IAC's produce specialized products
- IAC's process and transfer information
- IAC's directly help solve real problems

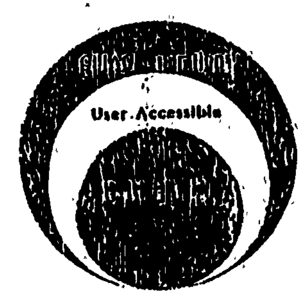
TASK ASSIGNMENT

- You prepare SOW
- IAC prepares proposal
- You review the proposal
- You forward MIPR to DESC
- DESC modifies contract

TASK CRITERIA

- Must be within scope of contract
- Require the special expertise of IAC
- Specific problem solution
- Definite deliverables
- Will not involve full scale development or production

CBIAC Abstract DB



DoD

Chemical Warfare/Chemical-Biological Defense

Information Analysis Center

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CBIAC
User Accessible Database

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CBIAC
User Accessible Database

CB Databases

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Inquiries	CRDEC
AF Properties DB	PLASTEC
Heat Stress DB	CARS
CANE	DTIC DROLS

The ASD Chemical Defense Data Base Program

by

Jim J. McNeely, Edward R. Zamejc, Keith J. Johanns,
Paul E. Hinds II, Tim Miller, Fred Meyer,

PREFACE

The USAF Aeronautical Systems Division (ASD), through the Air Force Wright Aeronautical Laboratories, is currently sponsoring the development of an automated Chemical Defense Data Base (CDDB). The initial development has been accomplished by Battelle Columbus Division. Battelle is currently under contract to advance the development of the data base. The development program is described below.

INTRODUCTION

Chemical warfare (CW) agents and the attendant decontaminants degrade aircraft and ground support equipment materials. Degradation may include the compromise of mechanical, chemical, optical, and electrical properties which result in an inability of a system to perform an intended function which, in turn, may lead to mission failure.

In order to address this vulnerability adequately and efficiently, system developers and design engineers will benefit by having access to a comprehensive technical database detailing the interaction between materials of construction and chemical warfare agents, decontaminants and chemical agent simulants. Armed with this information they can avoid use of materials that will degrade, choose materials that may degrade but retain desired physical properties needed in the structure, or treat materials so they do not degrade in the presence of CW agents or decontaminants. Information in the data base is described down to the experimental level so that the user is able to make judgments about the validity of the tests. A standardized confidence rating is also given for each test described so the user can rely on the reviewer's estimation of the validity of tests if desired.

OBJECTIVES

The objectives of this program are to collect, organize, and develop an automated mechanism for handling data describing the effects of chemical warfare agents, simulants and decontaminants upon materials and systems.

APPROACH

In order to develop a data base which best meets the user's needs, users were given a voice in determining how the data base was constructed. Representative aerospace contractors and Government personnel were invited to a workshop in which a Strawman of the data base was presented. The users then recommended revisions to the approach that would lead to the development of a data base that is more useful to them. A prototype of the data base was designed incorporating users' comments and a second workshop was held in which a demonstration of the data base was given. Additional user comments were obtained during the demonstration and subsequently integrated into the data base design. The prototype was then released to a selected group of aerospace contractors and Government facilities. A discussion of the data base features and operational requirements is provided as follows:

CDDB CONTENT

The data base contains information on literature documents relevant to the material effects of CW agents, decontaminants, and simulants. The data base is relational, menu driven, and can be manipulated to search for desired information on chemicals, materials, components, and degradation effects. Help screens are available throughout the data base. There are seven major categories of information in the data base as described below and illustrated in Figure 1. Most of these tables have layers of information within them.

(1) Bibliographic Tables
(2) Degradation Tables
(3) Test Facility Tables
(4) Community Members Tables
(5) Synonym Tables
(6) Chemical Properties Tables
(7) Test Schedule Tables

The Bibliographic Tables contain information about the document being referenced such as title, authors, performing organization, publication date, etc. An example is given in Figure 2. Associated with these tables are key word tables useful in search for specific subject areas or materials. There are also abstracts of the referenced document available.

The Degradation Tables contain technical information about the specific experiments performed in the referenced documents. There are four levels to the degradation tables as illustrated in Figure 3. An overall view or summary of the effects of chemicals on materials and components is available for the manager or design engineer. A very detailed description of the test conditions and test results on numerous physical and mechanical properties is also available for use by materials engineers or other specialists.

The Test Facility Tables contain information about facilities where chemical agent testing on materials is being performed.

The Community Members Tables contain organizational information about people who are involved in the testing of chemical agents and materials. The telephone numbers of engineers and scientists are provided to they can be contacted directly for additional information.

The Synonym Tables contain information about synonyms, acronyms, codes or other names used to describe chemicals, materials, and properties. These tables help standardize the terminology of the data base and aid in searching. Examples are given in Figure 4.

The Chemical Properties Tables contain physical property information about the CW agents and simulants. These tables are useful to identify specifics of the chemical threat and for general information on the agents and simulants.

The Test Schedule Tables contain information about plans for future experiments to determine the effects of CW agents, decontaminants, and simulants on materials or components. These tables are useful to avoid duplication of tests and to aid in development planning.

HARDWARE/SOFTWARE REQUIREMENTS

An IBM PC, XT, AT or 100% compatible computer equipped with at least one floppy disk drive and 640K RAM memory is required to access the data base. The data base itself is stored on a 20 megabyte capacity Bernoulli cartridge which requires a Bernoulli Box (20 megabyte by 20 megabyte) for operation. An internally fixed disk for the computer would not be allowed unless security requirements can be met. A color monitor and an IBM compatible printer are recommended.

In terms of software, a computer operating system much as MS-DOS or PC-DOS is required. The relational data base management system required for operation of the CDDB is Microrim's RBase System V. The estimated cost of the hardware and software is about $7000.

SECURITY REQUIREMENTS

This data base is classified SECRET/NOFORN and therefore, certain hardware and facility security requirements must be met. Approval from Defense Investigative Service (DIS) must be obtained by providing them with a Standard Practice Procedure Document prior to operating the data base. In general, the major requirements of DIS can be satisfied by either buying TEMPEST hardware, fabricating or buying shielded enclosures, employing red and black engineering, or establishing control space. The most cost effective means is through the use of control space in which there must be at least 30 meters from the system to any point of possible undetected interception of data. There must also be a one meter area around the system in which no pipes, phone lines, or power lines are present. No communication devices or fixed hard disks are allowed on the system. Cartridges and printed information from the database are considered classified information and must be treated as such according to DoD 5200.1R/AFR 205-1.

DISTRIBUTION OF THE DATA BASE

The CDDB Data Base will be distributed to users by the U.S. Air Force. Initially, a small group of users are being provided with a prototype of the data base and will be asked to make recommendations on the format, ease of use, etc. After the initial issue has been reviewed and modified as needed the data base will be made available to other Government facilities and to a select broader group of major manufacturers and contractors who have a need to know. Others with a need to know may access the information contained in the data base through the Chemical/Biological Information Analysis Center (CBIAC) located in Edgewood, MD. The data base cartridge will come with a User's Guide describing system operations.

SUMMARY

This program is intended to provide equipment designers with the information needed to ensure the chemical warfare (CW) survivability of aircraft and ground support equipment. The program includes organizing and disseminating existing information as well as developing a standardized structure for generating data needed in the future.

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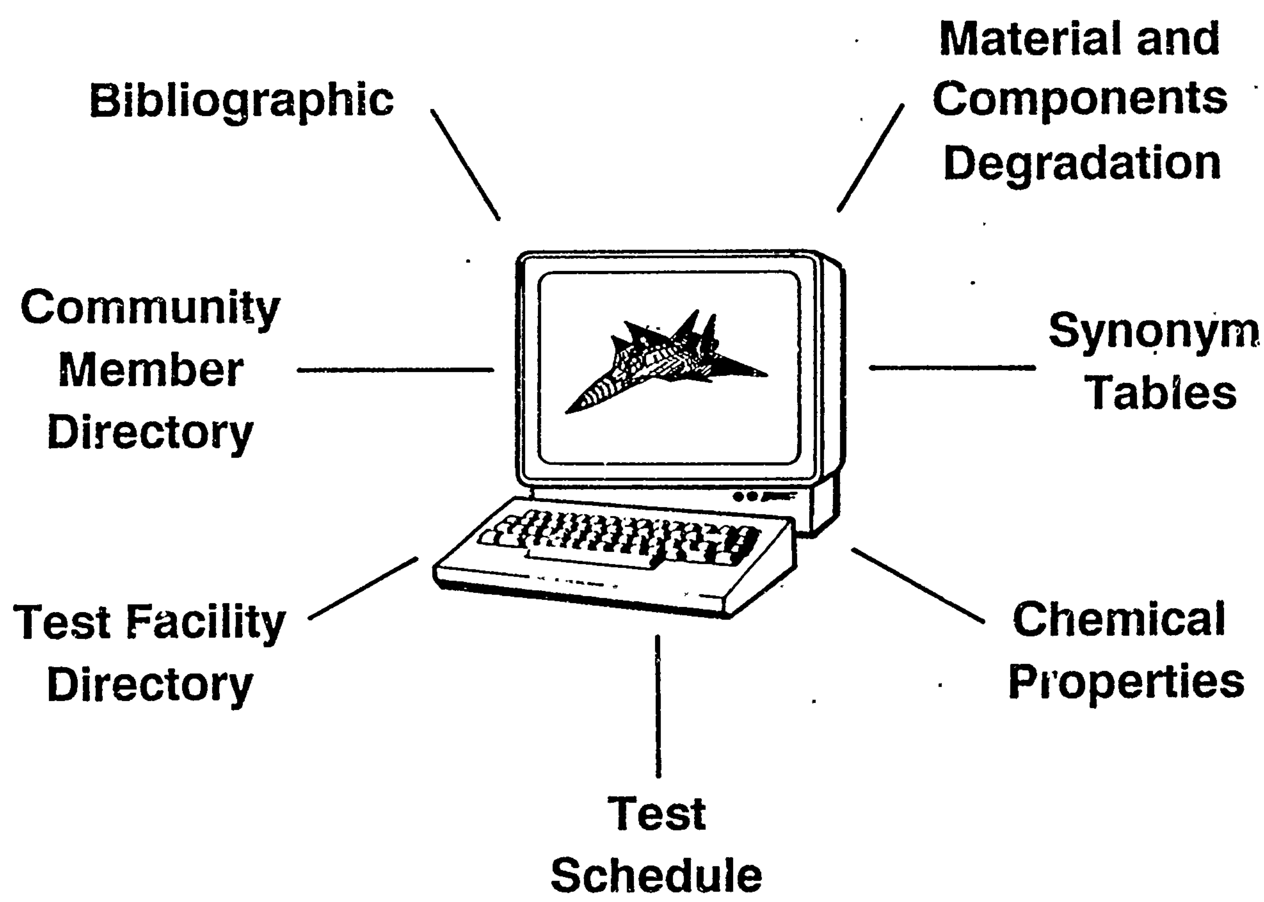

FIGURE 1. CHEMICAL DEFENSE DATA BASE RECORDS

UNCLASSIFIED
MAIN TABLE

```
Reference Number              :  1
Record Classification         :  UNCLASSIFIED
Title                         :  (U):  Interaction of Chemical Warfare Agent
                                  with Polymers of Military Interest
Personal Authors              :  Pfau, J. P.; Sharpe, R. E.; Jewett, S. K.;
                                 Huggins, R. L.; Dick, R. J.
Performing                    :  Battelle Columbus Division, Tactical Technology
    Organization                 Center, Columbus, Ohio  43220
PO Report Number              :  BATT-CSL-48-1
Sponsoring                    :  Chemical Systems Laboratory, Aberdeen Proving
    Organization                 Ground, MD  21010
SO Report Number              :  ARCSL-CR-82039
Contract Number               :  DAAH01-81-C-A2777, MIPR No. 1.38199
Publication Date              :  82/03/00
Classification                :  UNCLASSIFIED
Availability                  :  LIMITED-C
Government Accession Number:  ADB068512

****************************PLEASE ENTER CHOICE*****************************
*              NEXT     ABSTR     SUBJECT     MATERIEL     EXIT             *
****************************************************************************
```

FIGURE 2. BIBLIOGRAPHIC MAIN TABLE EXAMPLE OUTPUT

```
                    UNCLASSIFIED
         Degradation Descriptive Summary Table
                       LEVEL 1
Reference Number           :          242
Component Name             : -0-
Material Code              : A92024
Chemical Code              : STB
Test Type Number           :           4
Interaction Rating         : MAJOR
Rating Confidence          : HIGH
General Remarks
(U):   MAJOR RATING RESULTS FROM ROOM TEMP (23 DEGREES C).   AT 23 DEGREES
C. SEVERE EFFECTS ON MAX.ELO & RED AREA. MAJOR EFFECTS ON YLD.STR &
TN.STR.BRK & MD.ELA.T. NEGLIGIBLE EFFECT ON WEIGHT.  AT 71 DEGREES C.
MAJOR EFFECTS ON MAX.ELO & RED.AREA & MD.ELA.T WHILE REMAINING PROPERTIES
HAVE NEGLIGIBLE EFFECTS.  HIGH CONFIDENCE RATING DUE TO USE OF ASTM
METHOD & CONTROL SAMPLES.  AT BOTH TEMPS ( 23 & 71 DEGREES C). SAMPLES
WERE GRAY WITH SLIGHT PITTING BY BASELINE EXPOSURE TIME.

IMMMMMMMMMMMMMMMMMMMMMMMMMMMMPLEASE ENTER CHOICEMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM;
   NEXT      TESTSPEC  MATSPEC    CHEMSPEC  COMPSPEC  CHEMSYN    MATLSYN          :
   RATCRIT   REMARKS   LISTING    CONDSUM   EXIT                                  :
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM<
```

```
                        UNCLASSIFIED
                  PROPERTY SUMMARY TABLE
                          LEVEL 3
REFERENCE NUMBER :        242
COMPONENT NAME   : -0-
MATERIAL CODE    : A92024             CHEMICAL CODE    : STB
TEST TYPE NUMBER :          4         TEST RUN NUMBER  :          1
PROPERTY CODE    : MAX.ELO
----------------------------------------------------------------------

PROPERTY UNIT           : %
TEST SPECIFICATION      : ASTM E-8
TOTAL PROPERTY CHANGE   :    -29.9
PROPERTY RATING         : SEVERE

IMMMMMMMMMMMMMMMMMMMMMMMMMMMMPLEASE ENTER CHOICEMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM;
: NEXT      CHEMSYN   MATLSYN   PROPERTY   PROPDATA   CONDSUM    DEGSUM           :
: EXIT                                                                            :
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM<
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```
                       UNCLASSIFIED
                  Conditional Summary Table
                          LEVEL 2
REFERENCE NUMBER         :          242
COMPONENT NAME           : -0-
MATERIAL CODE            : A92024      CHEMICAL CODE     : STB
TEST TYPE NUMBER         :          4  TEST RUN NUMBER   :          1
NUMBER OF SAMPLES        :          5  EXPOSURE STATE    : LIQUID
EXPOSURE CONCENTRATION   : IMMERSED    EXPOSURE UNITS    : NA
EXPOSURE TEMPERTURE      :      23. C  EXPOSURE TIME     :        24. (HRS)
CONDITIONAL RATING       : MAJOR
DATA REMARKS:
     (U):  MAJOR RATING DUE TO:  SEVERE EFFECTS ON MAX.ELO AND RED.AREA;
MAJOR EFFECTS ON YLD.STR AND TN.STR.BRK AND MD.ELA.T; NEGLIGIBLE EFFECT ON
WEIGHT.

IMMMMMMMMMMMMMMMMMMMMMMMMMMMMPLEASE ENTER CHOICEMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM;
:  NEXT     CHEMSYN  MATLSYN  LISTING  PROPSUM  DEGSUM   EXIT                     :
HMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM<
```

```
                        UNCLASSIFIED
                    PROPERTY DATA TABLE
                          LEVEL 4
REFERENCE NUMBER :       242
COMPONENT NAME   : -0-
MATERIAL CODE    : A92024                     CHEMICAL CODE : STB
TEST TYPE NUMBER :          4
TEST RUN NUMBER  :          1
PROPERTY CODE    : MAX.ELO

TIME VALUE      PROPERTY VALUE     STANDARD DEVIATION      PCT. CHANGE
----------      --------------     ------------------      -----------
   0.5 (hrs)         15.6                 0.                  -4.9
   1.  (hrs)         14.1                 0.                  -14.
   6.  (hrs)         14.                  0.                  -14.6
  24.  (hrs)         11.5                 0.                  -29.9

PRESS ANY KEY TO CONTINUE
```

FIGURE 3. EXAMPLE OUTPUTS OF MATERIAL DEGRADATION TABLES (LEVELS 1 THROUGH 4)

CHEMICAL SYNONYM TABLE

```
         CHEMICAL CODE :STB
           COMMON NAME :SUPER TROPICAL BLEACH
CHEMICAL CLASSIFICATION :DECONTAMINANTS
        CHEMICAL FAMILY :N/A
          CHEMICAL NAME :-0-
       CHEMICAL FORMULA :-0-
   CHEMICAL COMPOSITION :BLEACHING POWDER CONSISTING PRIMARILY OF
                         DOUBLE SALTS Ca(OCL)2-2Ca(OH)2 AND
                         CaCl2-Ca(OH)2-H2O WITH CaO ADDED AS A
                         DESICCANT. NORMALLY DISSOLVED IN WATER:
                         566 GRAMS STB IN 1 LITER OF WATER.
   OTHER CHEMICAL NAMES :CHLORINATED LIME, BLEACHING POWDER
```

PRESS ANY KEY TO CONTINUE

MATERIAL SYNONYM TABLE

```
    MATERIAL NAME :WROUGHT ALUMINUM ALLOY 2024

    MATERIAL CODE :A92024

MATERIAL CATEGORY :METALS

  MATERIAL FAMILY :ALUMINUM

       TRADE NAME :-0-
```

PRESS ANY KEY TO CONTINUE

FIGURE 4. EXAMPLE OUTPUTS OF SYNONYM TABLES

COLLECTIVE PROTECTION FOR AIR BASES

by Maj. Gen. (Ret.) Pierre G. RICAUD
Member of the French Defense Science Board

The survival of personnel and support of air operations in a chemical environment, without, but minimum, degradation of performance, demand an efficient organisation of Chemical defence. Among the three phases of this organisation

- previous:prealert, warning and detection
- contemporary : individual and collective protection
- subsequent: decontamination

the collective protection of personnel, aircrafts and equipments is essential. It may be ensured, according to each base layout, through the association of

- Survival Collective Protection Shelters (SCPSs)
- Mobile Personnel Decontamination Centers
- Multipurpose NBC tents
- Chemical proof aircrafts shelters

SURVIVAL COLLECTIVE PROTECTION SHELTERS

The French Air Force bases are largely equipped with SCPSs, hardened against nuclear, chemical and conventional weapons, fulfilling three requirements :

- assurance of high mechanical resistance of the structure, while maintaining top tightness-rate even after impact
- adaptability to various uses : personnel shelters, command posts, hospital shelters (Fig.1)
- fast, simple and custombuilt installation.

The structure (Fig.2)

These requirements are satisfied by a modular concept of factory precast cylindrical reinforced concrete elements of adequate diameters (chiefly 250 or 320 cm), assembled by compressed flexible, airtight, elastomer gaskets. This structure, produced by BOHNA Co allows relative movements of the elements without unpairing the whole structure airtightness, easy transportation and building in a just underground configuration. The chemical free area is closed at each end by light alloy airtight doors lockable from inside and/or outside. These doors open either toward a L-shaped airlock or a control contamination area (CCA) or a connection module gathering f.e. personnel shelter and command post.

The air-lock is closed from outside by an armored cast steel door withstanding a 3.5 bars static overpressure direct shockwave. Antiblast valves located upstream filtration system, or on air inlets or outlets protect people and filters from an explosion shock wave of the same 3.5 bars. Located either in the airlocks or in a technical section of the shelter, a ventilation-filtration system overpressurizes the shelter, through ducts and air supply diffusers, with constantly renewed and expelled air. So the heat and carbon dioxide from the occupants are eliminated.

After a chemical attack, people enter or exit through a Contamination Control Area (Fig.3) made of the same structural elements. They can be decontaminated and undon their protective equipments along an access line, at an ingress rate of 30 people/hour. They walk successively through a Liquid Hazard Area and a Vapor Hazard Area, before entering the shelter through a Purge Air lock, where they stand a predetermined time. Along a parallel exit line, the egressing people receive an individual protective equipment.

<u>The ventilation/filtration systems</u>

These systems vary according to the type of shelter. They may be made of

- a set of removable high efficiency anti-aerosols (1800 m^3/h - 1000 cfm) and anti-vapor (150 m^3/h - 90 cfm) / filters inside casing of sizes accorded to the shelter capacity (Fig.4)
- or composite filters (vapors and aerosols) of medium (200 m^3/h - 120cfm) or high (1.000 m^3/h - 600 cfm) capacity (Fig. 5).

These systems, as the doors, ducts... and fixtures in general are manufactured and set by SOFILTRA-POELMAN Co.. BOHNA and SOFILTRA develop similar shelters for the Canadian forces in Europ (Fig.6 and 6 bis), while they realize for the US Air Force in Europ rectangular modular shelters (Fig.7 and 8). This design (Fig.9) gives a weaker mechanical resistance to a nuclear shockwave, offering however a very efficient protection against classical weapons. Its shape optimizes the available area for a same ground surface and offers a better occupancy capability with three lines for personnel access and exit.

These different types can hold an area hardened against the EMP effects, made of special modules, faradized doors...

The tests

The whole SCPS technology has been tested on a full scale against conventional, chemical and nuclear attacks: the main tests were realized

- during Direct Course event in 1983 when a half buried half shelter was exposed to the blast of 600 T ammonium nitrate fuel oil explosion equivalent to the blast wave from a 1 KT nuclear explosion. The half shelter was laid out 125 m away from zero point. No permanent alterations, no significant overpressure and only limited movements of the dummies inside the living unit were observed
- during Minor Scale test in 1985, simulating a 8 KT earthed nuclear blast, where a reinforced concrete door model, and two blast valves models were tested and proved reliable against the corresponding overpressure.
- at the U.S. A.F. Weapons Laboratory (Fig.11), the reinforced concrete structure (cylindrical or rectangular) resisted to blast effects and shocks from explosion of conventional surface or buried bombs from 500 to 1.000 lbs. The inside overpressure, essential for the chemical protection was also preserved.
- during CIGUE exercices in F.A.F. bases, for testing the personnel decontamination procedures, for flying and ground personnel.

The adaptation to medical purposes

These modular shelters can also be fit up as first aid medical units (Fig.12) with CCAs adapted for access and decontamination of wounded on stretchers, with medical treatment facilities and bathroom in the toxic free area, and with airlock for clearing of treated people on stretchers, eventually wrapped in casualty bags (Fig.13).

For this purpose THB Co has developped a new type of bag, made of wholly impervious material with a toxic barrier film (Fig.14), avoiding any hazard even if putted down on a highly contaminated ground or vehicle floor. The bag is pressurized with air filtered through a set of standard gas-mask canisters by a blower powered by batteries.

MOBILE PERSONNEL DECONTAMINATION CENTERS

These centers are set up for decontamination of personnel before they are allowed to go to a clear area (Fig.15). These 30 m^3 shelters made by SOFILTRA-POELMAN Co. allow 30 persons to go through per hour, are trailer-movable and

Best available

air-transportable. They are made of a light alloy frame and panels of complex aluminium-polyurethane. (Fig.16)

The liquid decontamination of shoes, clothes, mask and personal weapons is made outside under a tent, with fuller earth. Entering the shelters (Fig. 17 and 17 bis), people get rid of shoes and clothing with the exception of undergloves and protective socks they dispose of in the second room. There they exchange their contaminated mask for a new one. Then they enter the last room where they put on a clean set of clothes, and they walk out through the air-lock.

The shelter is pressurised with filtered air, which flows continuously upstream the personnel movement, at a flow of 180 m^3/h. Fresh air sucked by the blower passes through a dust prefilter, an anti-particulate filter (type 250m^3/h) and an anti-gaz filter (Type 90 m^3/h), and can be heated before entering the shelter.

MULTIPURPOSE NBC TENTS

On recede or reserve airfields, or on decentralized positions, mobile and fast erected shelters may be needed as forward emergency medical posts, or relief stations allowing people obliged to long protection posture to undon temporarily masks and protective clothing, to relax, to eat, drink, shave and relieve oneself.

For this purpose TMB Co. develops NBC tents (Fig. 18) made of special coated compound fabrics impervious to CW agents, similar to the casualty bag material. Light, easily transportable (on 1 T trailer), inflatable, it is self-supporting. A rigid, dismountable, frame rigidifies the tent and avoids it collapses if pierced.

Set up out of liquid contaminated areas, it protects against vapor and aerosol clouds. People must be liquid toxic free, before entering through an air lock, quickly cleared of toxic vapors by an airflow recycled through filtration unit (flowrate 600 m^3/h), while the 25 m^3 of shelter itself are pressurized with air filtered through a second filtration unit at a flow rate of 90m^3/h without recycling.

The two ventilation /filtration units are SOFILTRA-POELMAN products.

The normal airlock (1m x 1 m X 2m high) may be replaced by an extended one (1m x 2 m x 2 m high) for entering stretchers.

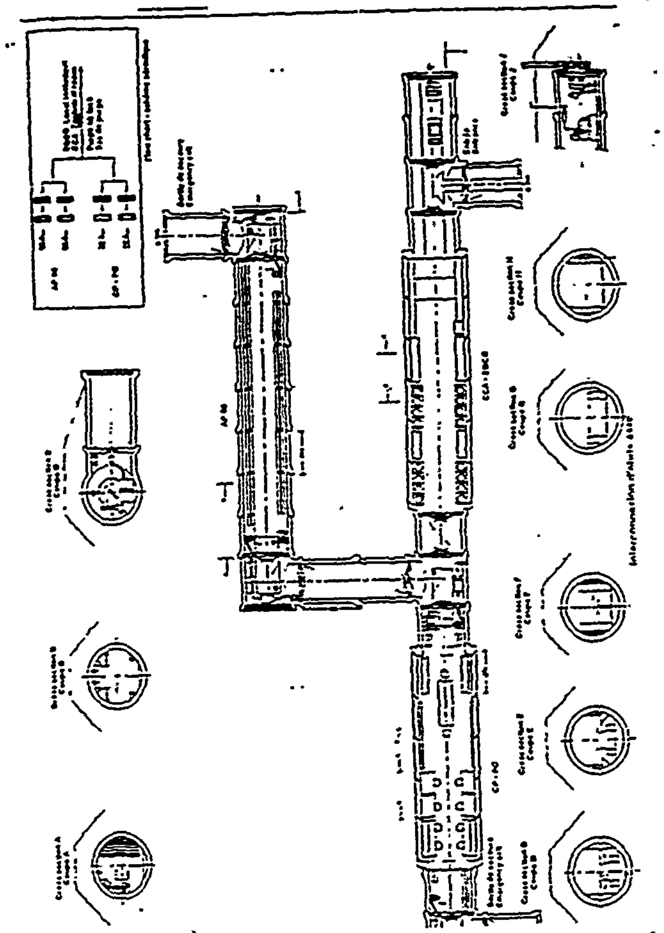
Air locks may also be used for connecting several shelters.

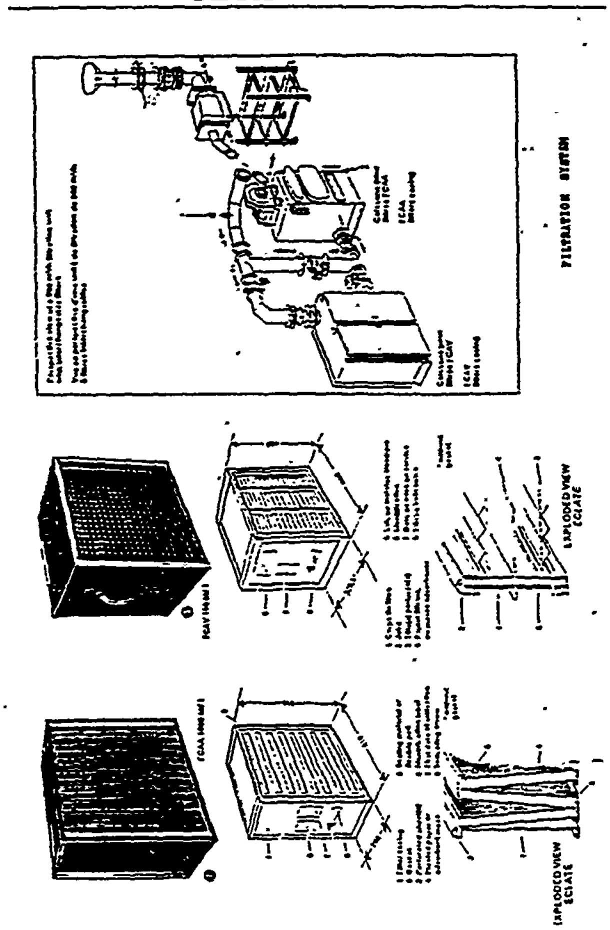
CHEMICALLY PROTECTED AIRCRAFT SHELTERS

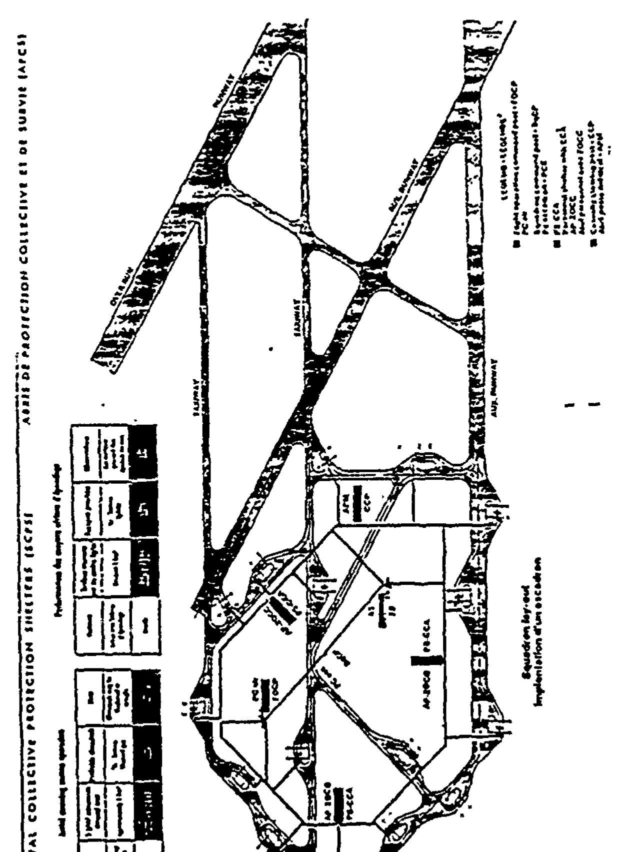
The same special THB fabrics can add chemical protection to classical aircraft hangars by an "over the roof" housing, impervious flexible doors under the forward arch, a flexible impervious flap at the jet exhaust, an internal airlock for personnel entry. (Fig.19)

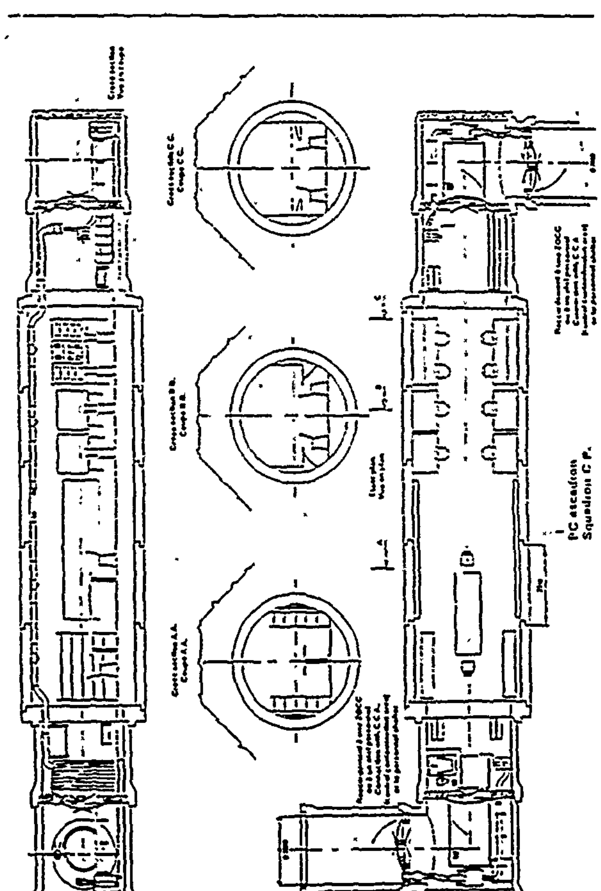
An air ventilation/filtration system allows a minimum pressurization against penetration of toxics.

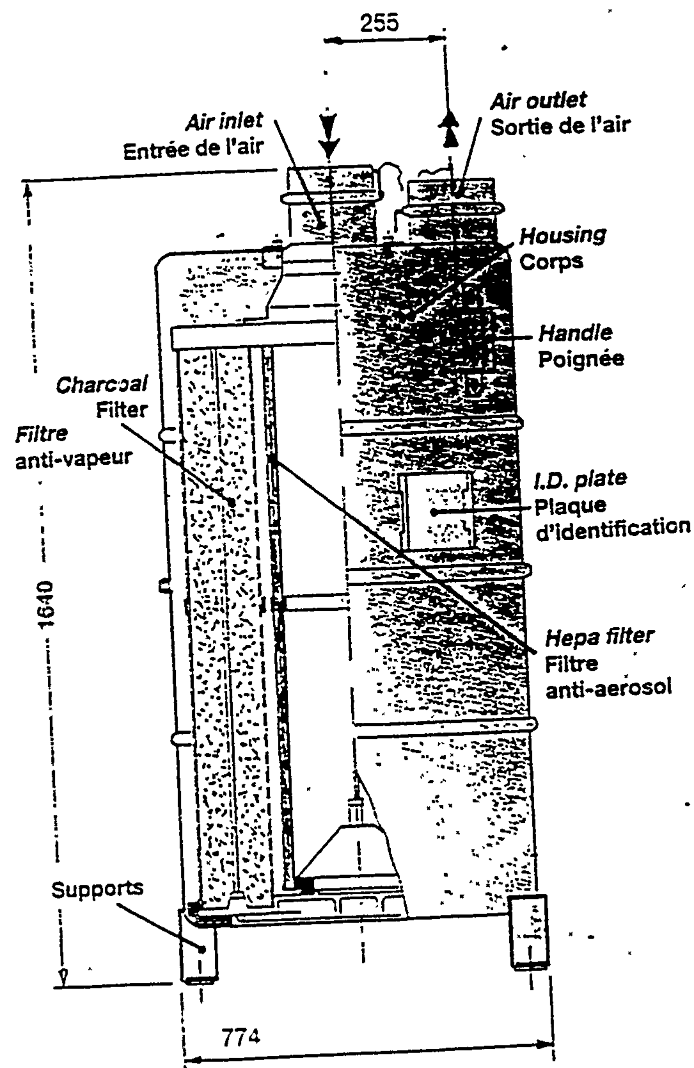
The combination of these different elements, may answer most needs of various air bases, adaptable to a wide range of functions and configurations. It may allow high operational base performance even under or after chemical attack.





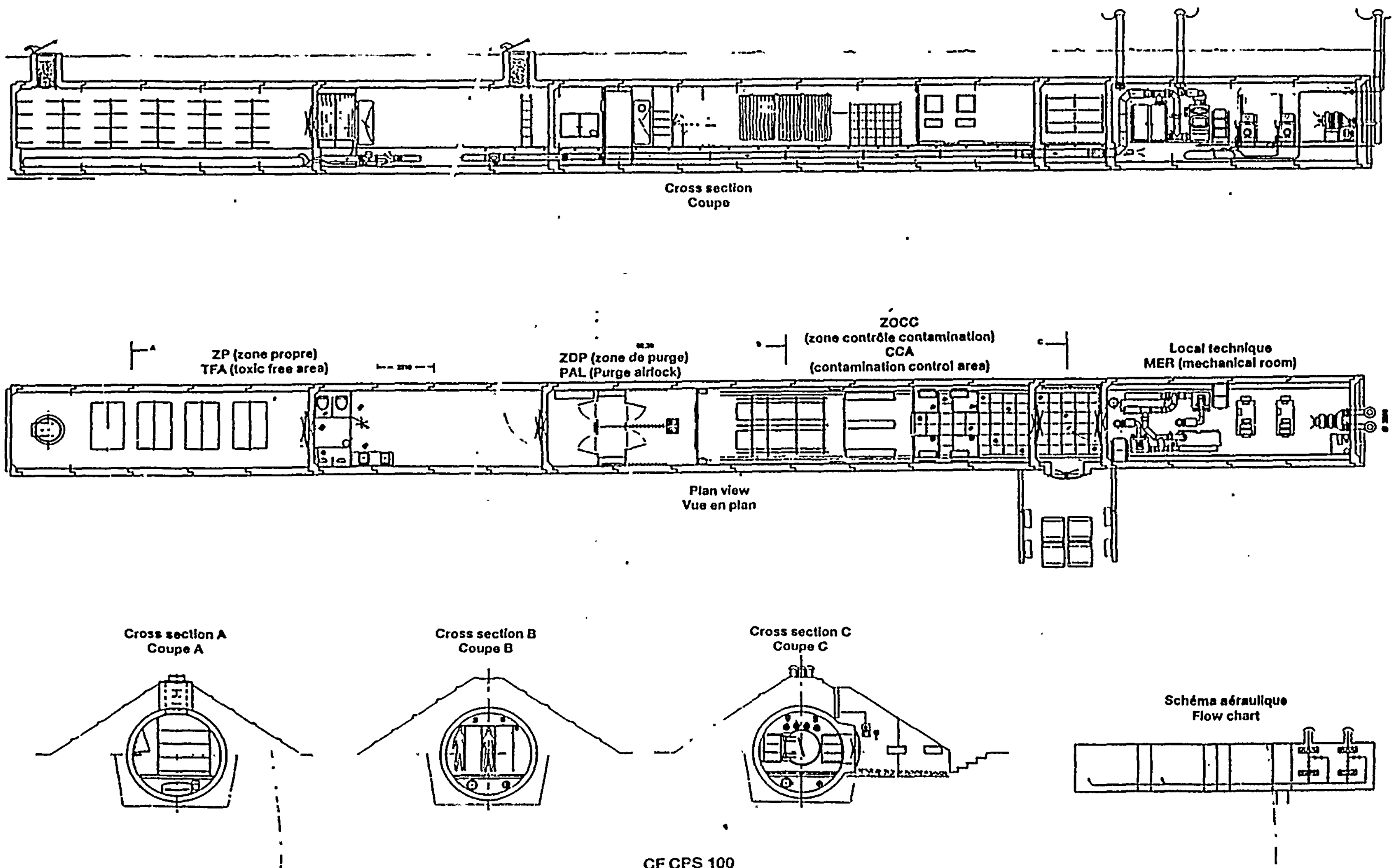






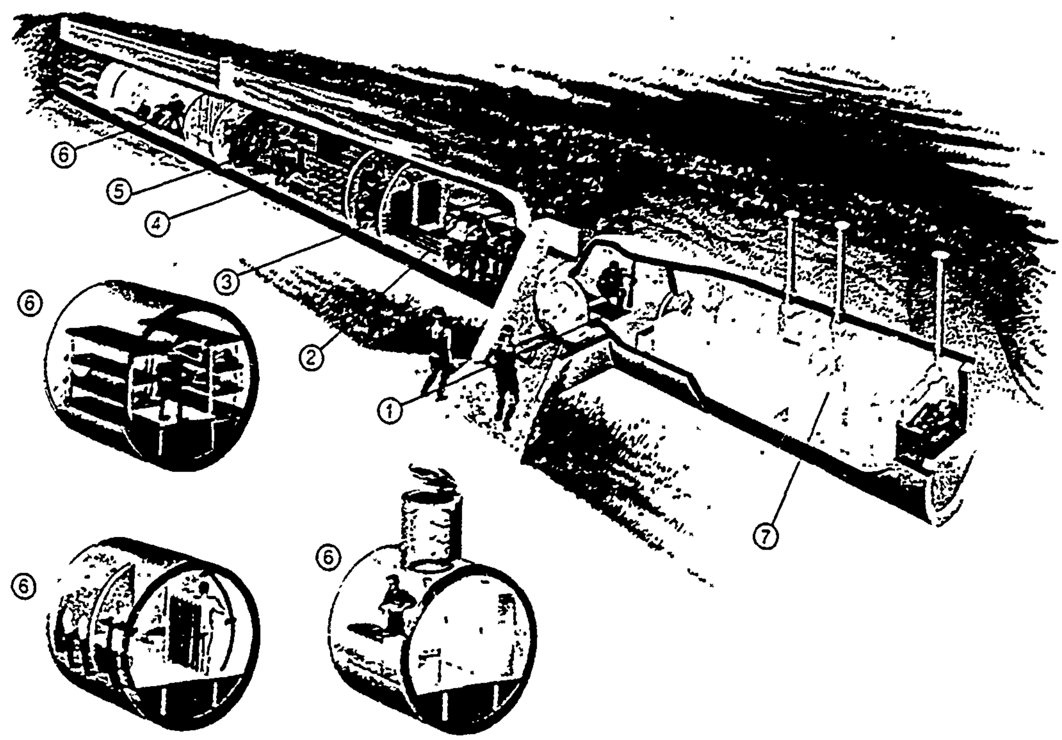
COMPOSITE FILTER

Fg 5


Cross section
Coupe
ZP (zone propre)
TFA (toxic free area)
ZDP (zone de purge)
PAL (Purge airlock)
ZOCC
(zone contrôle contamination)
CCA
(contamination control area)
Local technique
MER (mechanical room)
Plan view
Vue en plan
Cross section A
Coupe A
Cross section B
Coupe B
Cross section C
Coupe C
Schéma aéraulique
Flow chart
CF CPS 100

Abri avec module d'accès

Shelter with ingress - egress module



Fi. 6 bis

SCPS 84

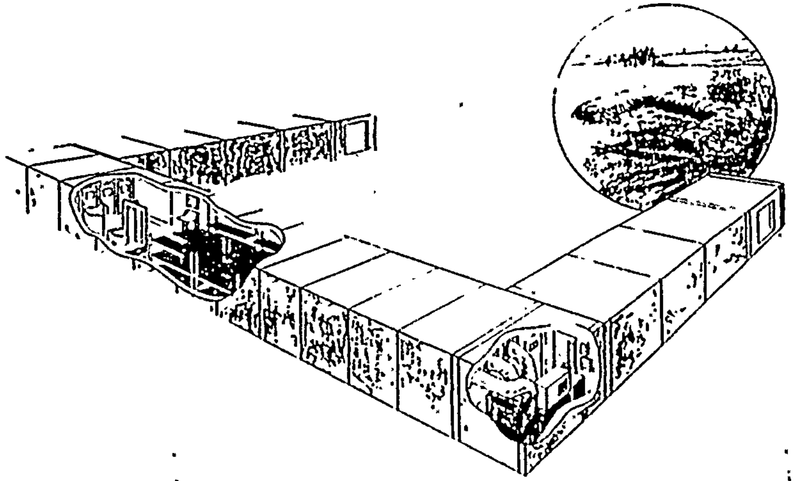
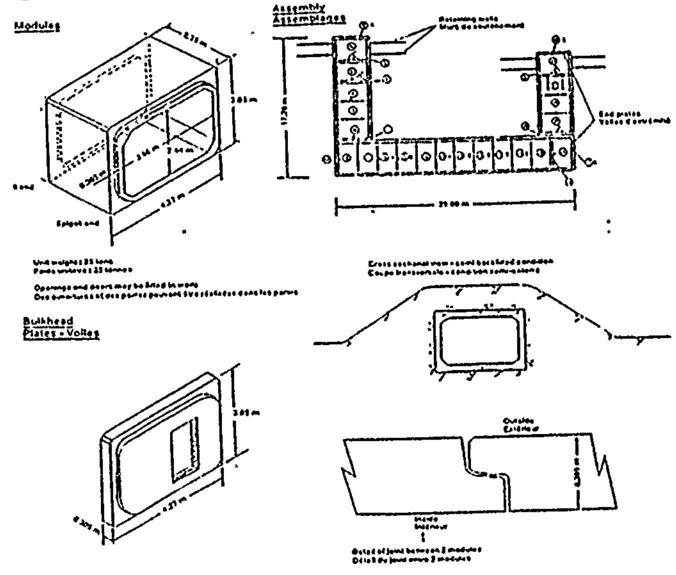


Fig 7



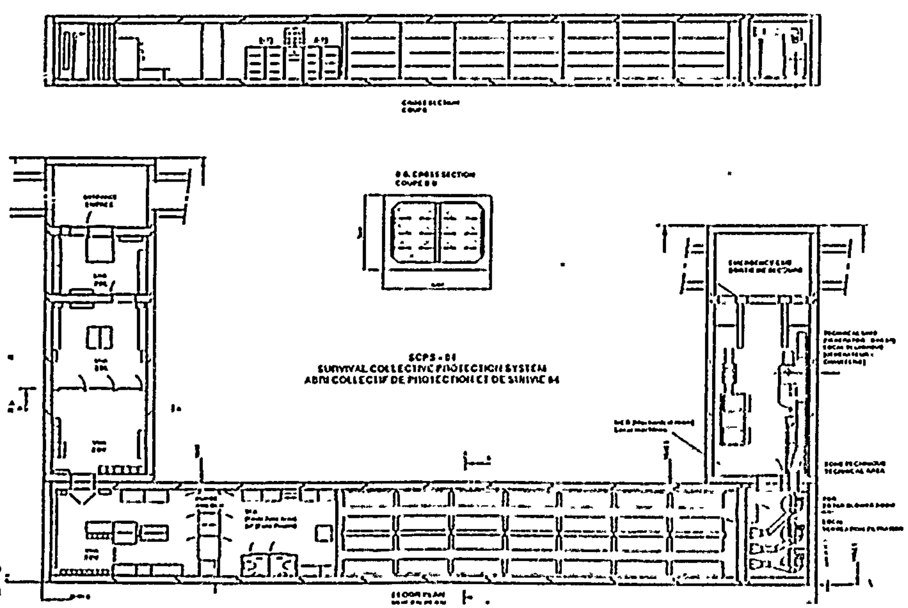
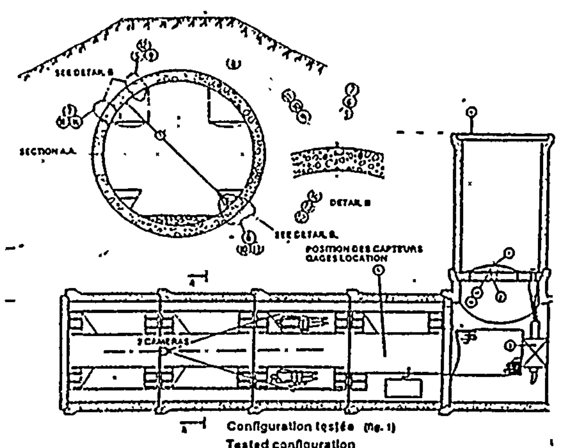


Fig 8

Nuclear blast effects on the BONNA-SOFILTRA
modular semi-hardened shelter
Direct Course event 1983



U.S.A.F. WL (U.S. Air Force Weapons Laboratory)

Assessment of modular structures in blast and shock environment by the U.S. Air Force

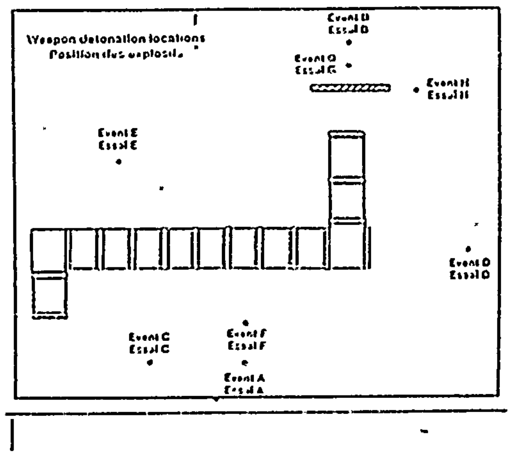


Fig 11

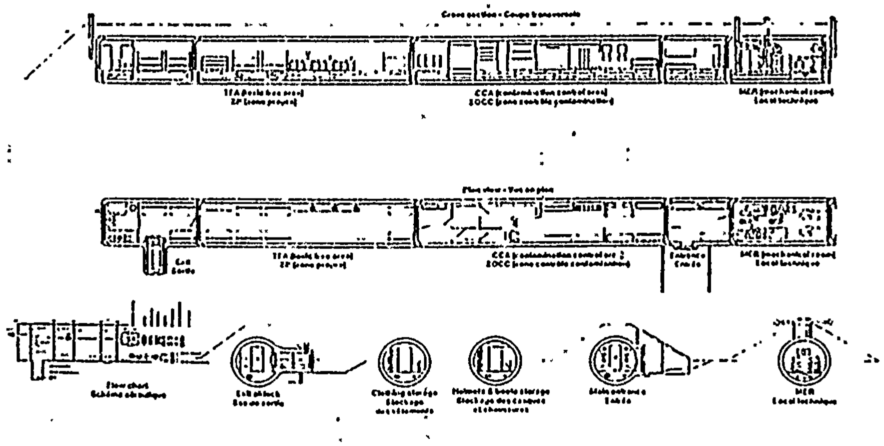
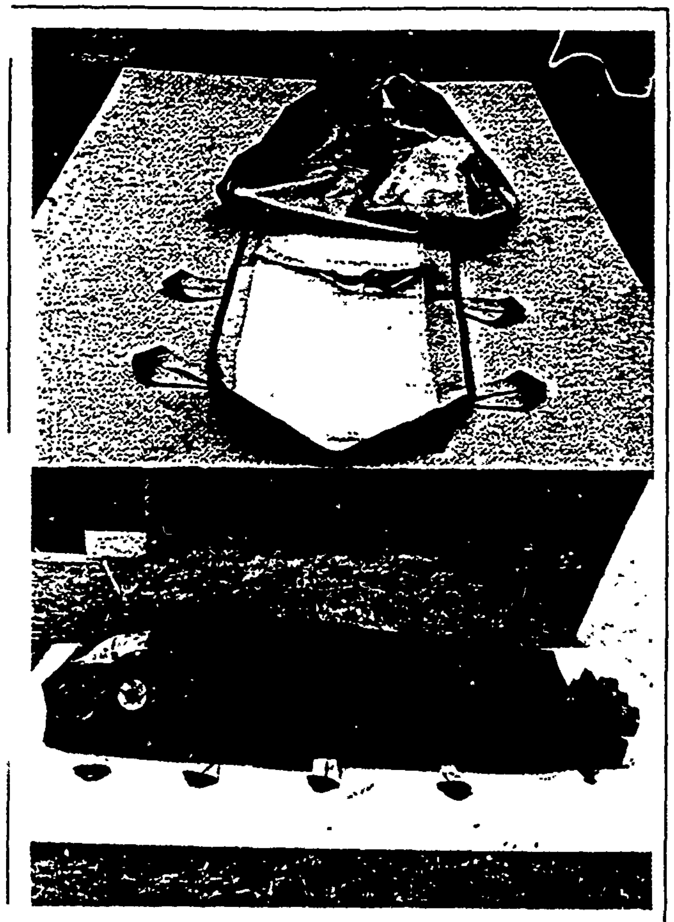


Fig 12

CASUALTY CLEARING AND DECONTAMINATION POST



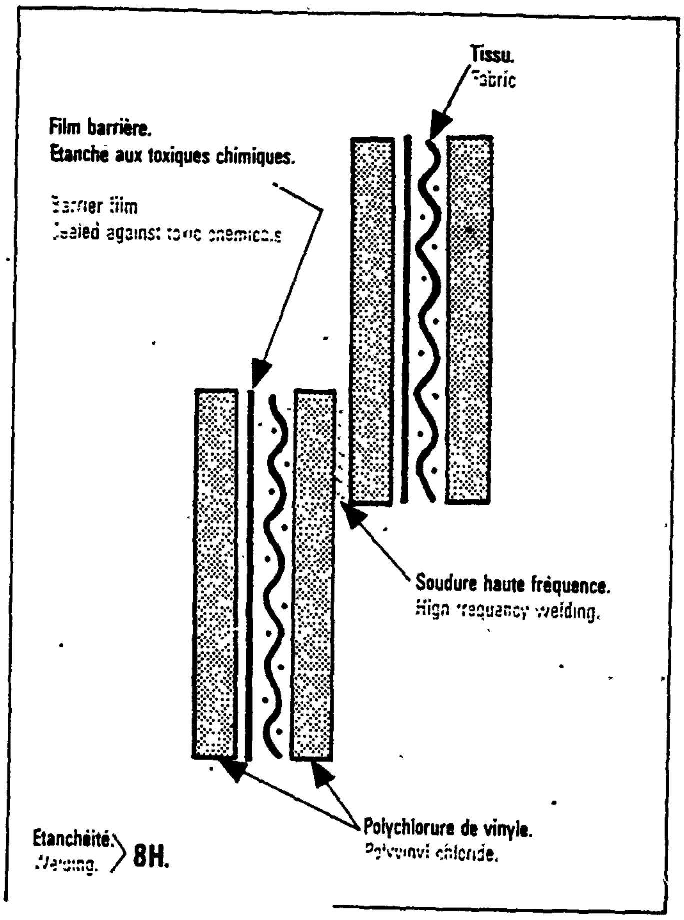
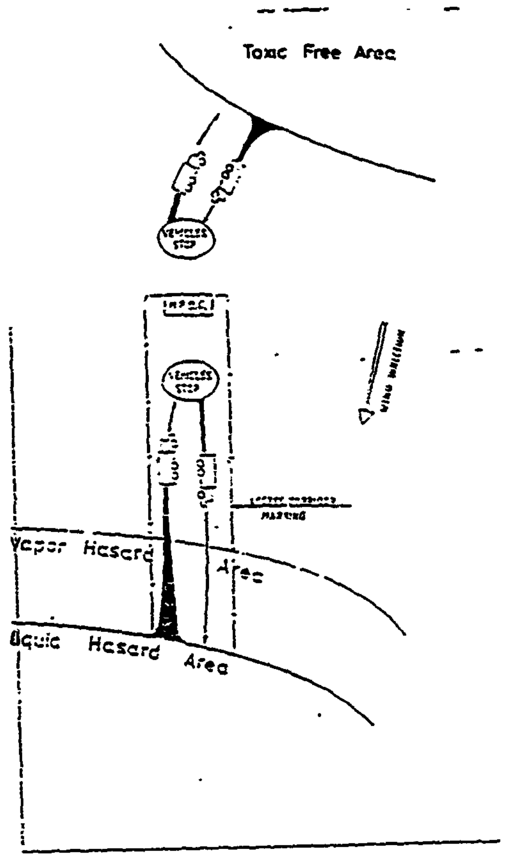
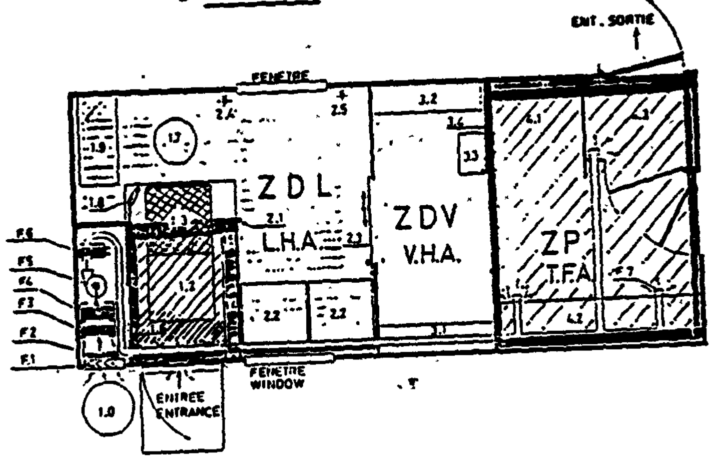

Tissu.
Film barrière.
Etanche aux toxiques chimiques.
Soudure haute fréquence.
Polychlorure de vinyle.
Etanchéité.
8H.

Fig 14


Toxic Free Area
VEHICLES STOP
VEHICLES STOP
Vapor Hasard Area
Liquic Hasard Area

CMDP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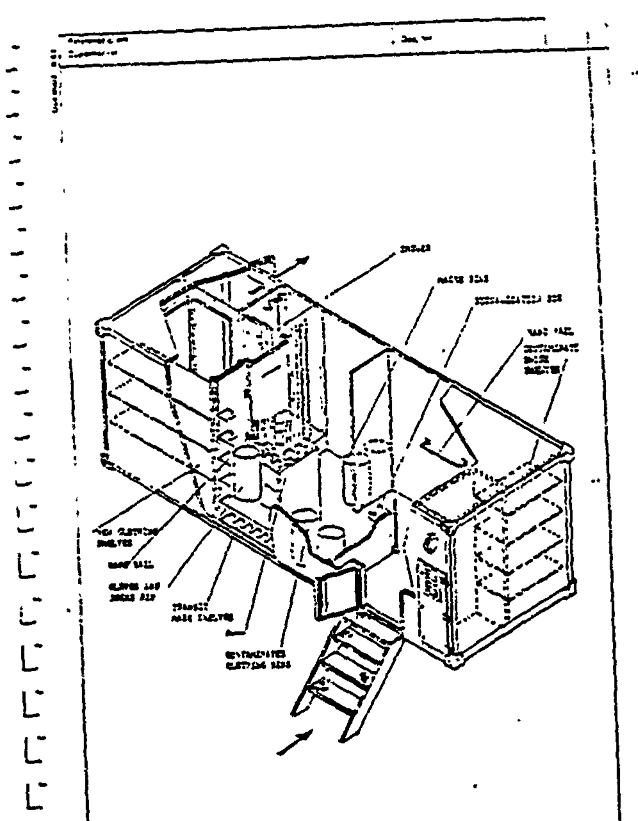

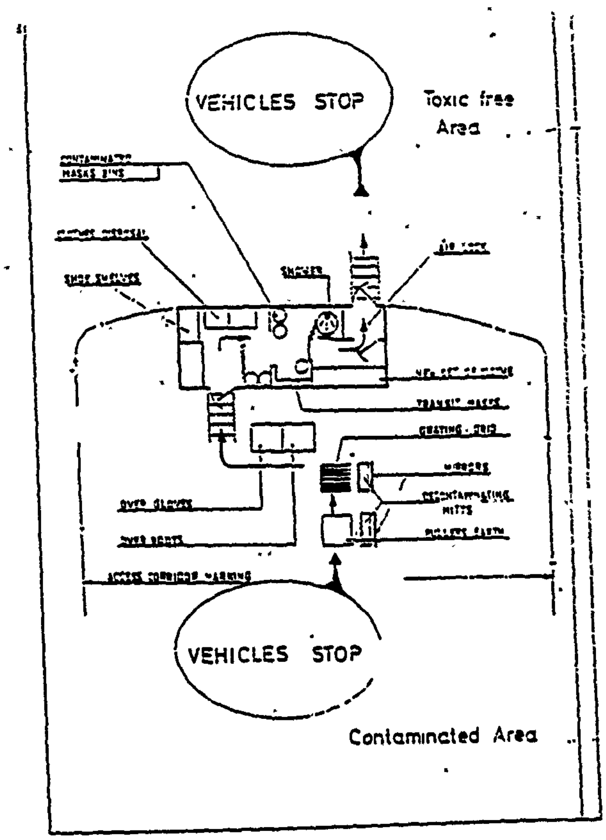
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Toxic free Area
VEHICLES STOP
Contaminated Area

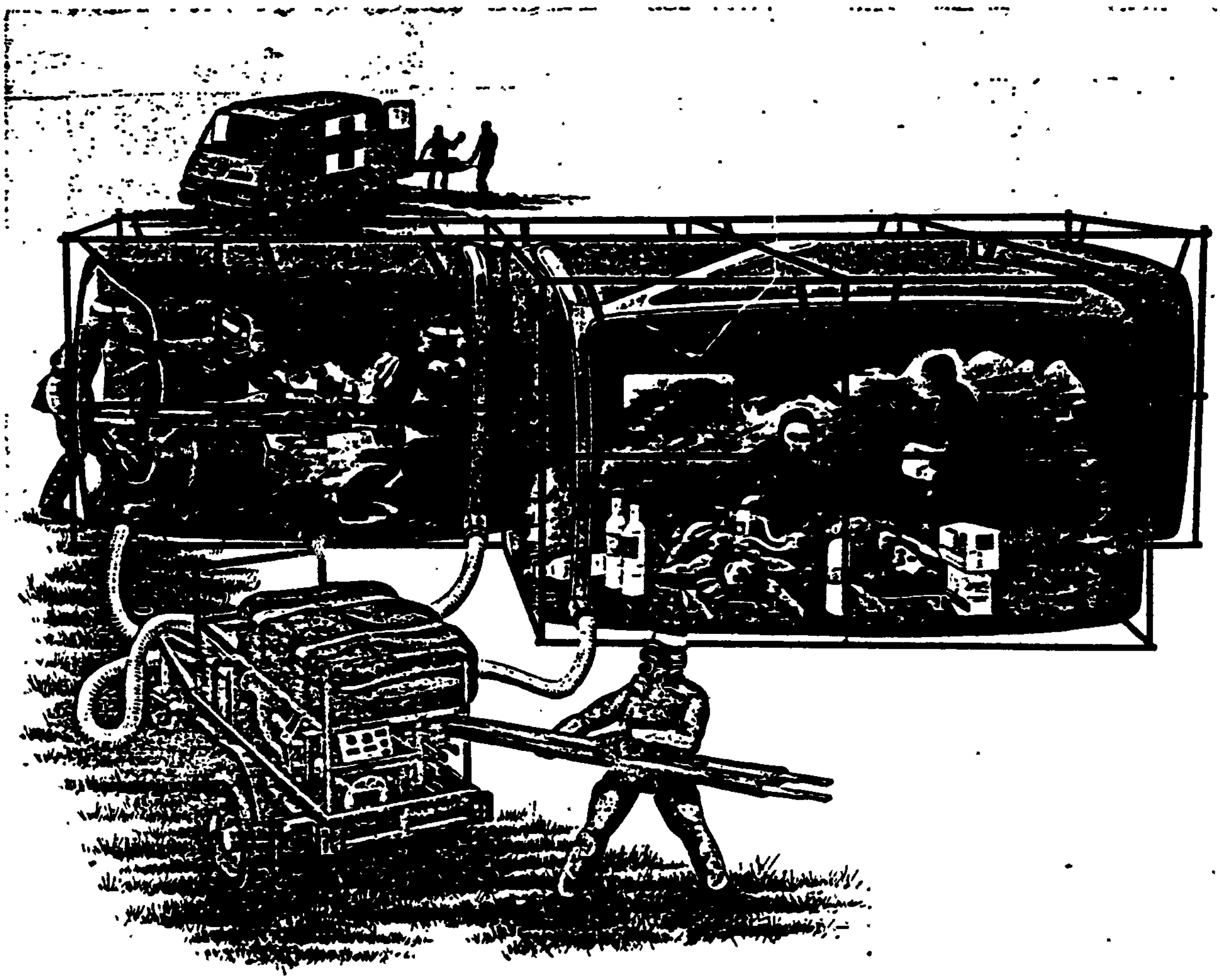

Fig 18

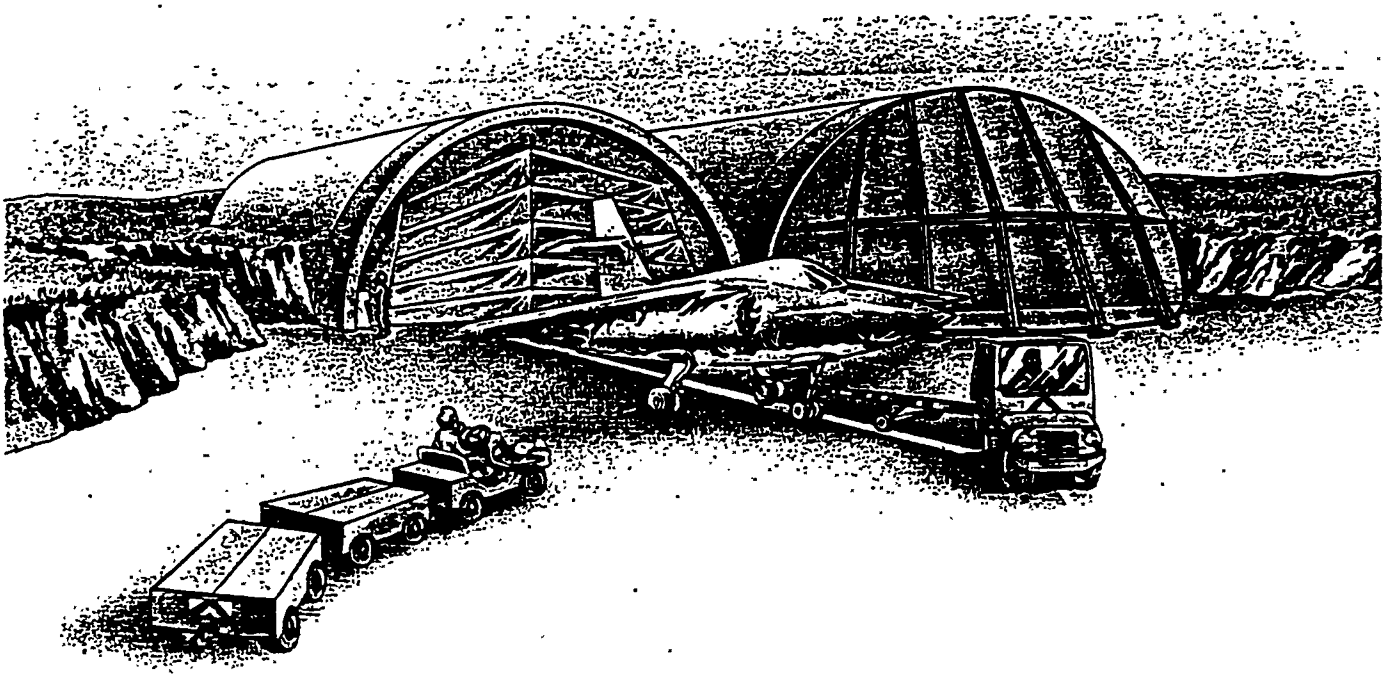

Fig 75

SURVIVABLE COLLECTIVE PROTECTION SYSTEM

(SCPS-2)

MR. CURTIS MOSER

1. The objective of the Survivable Collective Protection System (SCPS-2) program is to develop, test, and field a shelter system that provides protection from both chemical and conventional weapons. The shelter is designed to provide long term rest and relief (12 hours) in a shirt/sleeve environment. The total Air Force requirement is for approximately 1700 shelters in high threat locations in the European and Pacific theaters.

2. In 1982 the French AMF-80 Shelter was evaluated as a possible near-term solution to the USAF collective protection requirement. Based on the evaluation results, a 1983 USAF General Officer Council (GOC) recommended a limited production buy of 30 shelters. However, in 1984 Congress deferred the funding and the AMF-80 (SCPS-1) never entered the USAF inventory. In the meantime, development work had started on a U.S. shelter design (SCPS-2) which lead to a 1984 GOC production go ahead. The initial SCPS-2 production contract was awarded September 1985.

3. The SCPS-2 shelter consists of 21 rectangular precast concrete modules, each weighing approximately 25 tons. Each shelter contains a 40KW diesel generator and three MIL-STD, KMU-450 filter blowers. Each blower provides 600 CFM of filtered air which yields a nominal overpressure of approximately 1.5 inches H_2O. The shelter is capable of supporting 84 people per 12 hour shift for 96 hours without resupply. Optional heating and air conditioning units are available.

4. The shelter consists of three primary areas: the Contamination Control Area (CCA), the Toxic Free Area (TFA), and the Mechanical Equipment Room (MER). Personnel enter into the CCA where they are dusted down with a sorbent powder. Outer garments are then removed and stored for future re-use. Personnel process through a series of airlocks into progressively cleaner areas, leaving contaminated clothing behind. A final 3-minute air shower is taken immediately prior to entering the TFA. Once in the TFA, personnel have access to food, water, toilets, and a cot. The MER contains the 40KW diesel generator, a 300 gallon fuel tank, filter blower units, and optional heating and air conditioning equipment.

5. One hundred and fifteen shelters are presently on contract for installation in Europe. It is expected that approximately 1500 shelters will be installed in Europe through the mid 1990s. The initial production contract for the Pacific theater is expected to be awarded October 1987. Approximately 150 shelters are planned for the Pacific region.

NATO

INTERNATIONAL CONFERENCE ON

MAINTENANCE OF AIRBASE OPERATIONS
IN A CHEMICAL WARFARE ENVIRONMENT

TRANSPORTABLE COLLECTIVE PROTECTION SYSTEMS PAPER

1st Lt Regina M. Connor
ASD/AESD

The Transportable Collective Protection Systems (TCPS) program is a development program managed by the Chemical Defense Division, Life Support System Program Office (SPO), Wright-Patterson AFB, Ohio. This paper describes the program requirements, background, structure, and systems.

The objective of the TCPS program is to provide chemical protection to existing transportable shelters. Providing these collective protection areas will enhance the combat operational capability of deployable forces by permitting rest and recuperation outside the chemical protective ensemble. Our emphasis right now is to provide chemical protection to three existing bare base shelters.

The basic performance requirement for the TCPS is that it provides protection from chemical warfare environments for 12 personnel per 12-hour shift. This basic unit capacity is derived from the billeting standard for the TEMPER tent. To enter and exit the collective protection area (toxic free area) an ingress/egress system and procedures are required. In the TCPS program an enclosed, pressurized Contamination Control Area (CCA) is being developed to provide this capability. The TCP systems must operate in a contaminated environment for 96 continuous hours, 48 hours without resupply. By requiring only 48 hours of consummables, shelter size can be minimized. Required strike/erect time is 60 minutes. This time does not include the time required to erect the main host shelter. Since we are dealing with tentage materials, we must have the capability to repair small holes which will occur during normal operation. Duct tape will be used to repair most small punctures.

In February 1986 a proof of concept demonstration was held at Brooks AFB, Texas. The purpose of this effort was to better define a transportable CCA system that could interface with different existing shelters. The positive results of this demonstration fed directly into the development specification which was recently put on contract.

TCP systems acquisition approach employs two primary contracts. The first of these, the Army Simplified Collective Protection Equipment - Preplanned Product Impovement (SCPE-P3I) program, was awarded to ILC Dover, Inc. This program is based on the M20 room liner system which is now in production. Under the SCPE-P3I program liner systems for the TEMPER are being developed. The TEMPER is a modular tent system that comes in the basic size 8 ft long by 20 ft wide. The 8 ft long modules can be connected together to form tents of varying lengths. Common lengths for the tent are 32, 48 and 64 ft. The liner system developed for this tent is also modular allowing the shelter to be used in a chemical warfare environment the same way it is in an uncontaminated environment. Under this Army contract a liner system for the EXP shelter is also being developed. This shelter is only used by the Air Force in a bare base environment. In addition to these liner systems, the SCPE-P3I program will improve the motor blower and entry/exit capabilities (airlock) of the baseline M20 system.

Our other main effort is the Air Force Integration Program. This effort was awarded July 1987 to ILC Dover. This effort consists of two main parts. One is developing a system to provide chemical hardering to the expandable shelter/container (ESC). This system will consist of a liner, filter/blower system, and support kit. The other main part is the development of the Contamination Control Area (CCA). It will be a modular system designed to go with the three shelters we are working with, the EXP, TEMPER, and ESC.

All of the above systems will be operated with existing b_ _ base generators and ECUs.

Chemically Hardened Shelter System

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BACKGROUND

The battlefield of the future will feature heavily armed, highly mobile ground forces that will clash with unprecedented violence. There is an extremely high probability that the ground forces of the United States and its allies will be subjected to chemical weapons. The introduction of chemical weapons onto the battlefield will cause a rapid degradation of unit effectiveness by: requiring cumbersome and heat stress inducing protective clothing; hindering troop movement into specific areas; rendering stored materials and equipment inaccessible or nonusaable; and producing large number of casualties in poorly trained and unprepared units.

Collective protection is one of the key elements in providing battalion, division, and corps level health services support in toxic environments. Without collective protection, medical theaters will be forced into protective equipment which will render them incapable of providing any effective medical care.

At present, the M-51 Collective Protection Shelter is the only fielded system that provides collective protection against chemical and boilogical (CB) agents at the battalion and division medical levels. Medical units using the M-51 identified serious design and operational deficiencies that degrade their capabilities to provide effective medical care. Deficiencies are: insufficient floor space and personnel thoroughput; excessive weight and deployment time; lack of natural ventilation and insufficient prime movers.

The U S Army Natick Research, Development and Engineering Center (USANRDEC) was directed by the Department of the Army to develop a replacement for the M-51 Collective Protection Shelter. Natick accepted this responsibiltiy recognizing that, although the M-51 replacement will be primarily developed for medical use, a highly-mobile collective protection system has potential for other applications. Furthermore, less-mobile corps level medical facilities are susceptible to collateral CB agents exposure and thus should be CB hardened.

OBJECTIVE

Develop a family of chemically protected enclosures for all theaters of operation. Development will include highly mobile Battalion Aid Stations (BAS) and Division Clearing Stations (DCS) for medical and other applications, and less mobile shelter complex for field hospitals.

APPROACH

A highly mobile chemically protected unit, or Battalion Aid Station (BAS) will be designated for emergency medical use in the forward battle areas. This will consisit of a foldable shelter offering 300 and/or 400 sq ft of working space. The shelter, power systems, and medical equipment will be accommodated by a High Mobility Multi-purpose Wheeled Vehicle (HMMWV). The 400 sq ft shelter system will house the power system in a 3/4 ton trailer, while the 300 sq ft shelter will house the ancillary equipment within the HMMWV (ambulance/rigid wall shelter).

The Division Clearing Station (DCS) will be the next echelon of operations and will provide more extensive medical care. The DCS consists of two BAS complexed together through a suitable airlock of passageway.

At echelons above division, CB hardened International Standardization Organization (ISO) rigid wall shelter will be complexed with CB hardened TEMPER tents (Tent, Extendable, Modular, Personnel) to provide the highest level of medical care. At the Corps Hospital level patient accomodations range from 60 to 400 beds.

ADVANCED AIR PURIFICATION SYSTEMS

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INTRODUCTION

The purpose of this paper is to give an appreciation of the current direction being taken by the U.S. Army in developing improved air filtration technology for protection against the effects of Nuclear, Biological and Chemical (NBC) agents. This paper will address current filtration systems, the technologies considered as potential candidates, the status of the technologies chosen for further development, and the direction being pursued into the near and far term.

THREAT

The potential employment of NBC weapons by an adversary in any future military conflict is of primary concern to the U.S. Armed Forces. The threat posed by the Soviet Union and other WARSAW Pact countries include a variety of tactical munitions with the potential for NBC warheads. A variety of tactical Ballistic Missiles, long range rockets, tube and rocket artillery are NBC capable ground-force systems. The air delivered NBC threat includes bombs, missiles, rockets, and spray tanks. These weapons can pose both on ground and airborne threat to a combat system depending upon the dissemination method. The variety of hazards include persistent and nonpersistent chemical agents of the following classifications: nerve, blood, blister, choking, and incapacitants. Toxins and biological agents are also assumed to be available to Soviet commanders. The nuclear threat will be from both ground and air burst munitions. The protective requirements, therefore, involves NBC protection against particulates, vapors, gases, aerosol liquids, and thickened liquids.

CURRENT AIR PURIFICATION CAPABILITY

The present collective protection (CP) filtration system used as the main defense against a Chemical-Biological (CB) attack is an air filtration system utilizing a high efficiency aerosol filter media and a granular vapor/gas adsorbing media. This type of air purification system is capable of removing greater than 99.97 percent of particulates having a mean particle diameter of 0.3 microns and of adsorbing all known and/or suspected chemical warfare (CW) agents at an efficiency of greater than 99.999 percent. The granular adsorbent currently employed in NBC filters is ASC Carbon which is an activated carbon impregnated with copper, chromium, and silver salts. The incorporation of these metal salts with activated charcoal produces an adsorbent which will either retain toxic gases by physical adsorption or destroy them by chemical reaction. Even though these current air filtration systems are quite effective, they do possess several undesirable features. These filters have a finite life-time and must be periodically replaced to insure that adequate protection is always available to CP structures and individuals within these structures. The logistics involved with supply and replacement of air filtration system components (filters) impose an added burden which impacts operational effectiveness.

NEW FILTRATION TECHNOLOGIES

Potential alternate air filtration technologies were analyzed during the 1980-1985 timeframe by the Government with the assistance of Battelle Columbus Laboratories and Life Systems Incorporated. Battelle performed a search of potential technologies resulting in four recommended concepts. Life Systems Incorporated evaluated these recommended technologies plus others. The following list provides the technologies considered as potential CW agent removal technologies:

- o Catalytic Oxidation
- o Electrical Discharge Plasma
- o Regenerative Adsorptive
- o Regenerative Life Support Based Upon Aerospace Technology
- o Thermal Decompositions
- o Laser Decompositions
- o Combustion
- o Chemical Decomposition
- o Microwave Decomposition
- o Membrane Process
- o High Pressure Filtration

These technologies were ranked according to their estimated weight, volume, and power requirements. Those which offered the greatest potential for military use were included in the U.S. Army Chemical Research, Development and Engineering Center (CRDEC) development plan. Discussions and status on the technologies (regenerable filtration, catalytic oxidation, electrical discharge plasma, and high pressure filtration) that were considered viable candidates follows.

REGENERATIVE FILTRATION TECHNOLOGY

Two concepts are being explored based upon enchanced adsorption of CW agents at low temperature and/or high pressure. The developmental programs, Temperature Swing Adsorption/Desorption (TSA) and

Pressure Swing Adsorption/Desorption (PSA), are based upon adsorbing contaminates at low temperature or high pressure and desorbing (regenerating) at high temperature or a lower pressure.

1. LOW TEMPERATURE REGENERATIVE FILTER SYSTEM (LTRFS): The LTRFS is an advanced air purification concept based upon thermal swing adsorption/desorption technology. The system consists of a Chemical Agent Removal System (CARS) and an Environmental Control Unit (ECU). The CARS consists of two sorbent beds with associated valving and heat exchangers. Contaminated air is cooled to 35-40^{o}F in the ECU and filtered through one sorbent bed while the second sorbent bed is being regenerated at a higher temperature (400-500^{o}F). By switching the valves, the two sorbent beds are cycled through adsorption/desorption modes, thereby, providing continuous protection. The enhanced adsorption at low temperature also negates the need for an impregnated activated charcoal or exceedingly large filtration beds as the sorption media.

A full scale 150 cubic feet per minute (cfm) test stand was developed and tested with chemical vapor simulant and chemical warfare agent by the Government. The LTRFS met the design specification goals and demonstrated the feasibility of the LTRFS technology.

A full scale 150 cfm prototype has been developed and integrated on an experimental tank. An ongoing effort is being performed to improve the sorbent media of the CARS unit. To date, this effort has demonstrated significant promise in reducing the size of filter beds or, alternatively, increasing capacity for highly volatile chemicals.

2. PRESSURE SWING ADSORPTION/DESORPTION (PSA): PSA technology uses pressure as the controlling adsorption/desorption variable. This process uses a filtration media to separate contaminants from contaminated air allowing breathable air to continue towards the effluent end of the filter system. A fraction of the purified air is then used at a reduced pressure to regenerate (desorb) the filtration media.

Two avenues have been pursued by CRDEC on this technology effort. First, a PSA laboratory test stand has been developed that has the flexibility to conduct experimental parametric studies with both chemical agent simulants and chemical agent warfare compounds. The parameters include studies on sorbents, pressures, cycle times, and other potential design factors. These parametric studies will be initiated in 1987. A concurrent effort is being performed to develop a full scale 250 cfm PSA prototype for the U.S. Navy. The prototype will be tested with chemical agent vapor simulant in 1988.

CATALYTIC OXIDATION

Catalytic oxidation technology is based upon contaminated air being heated to a high temperature and passed through a catalytic reactor where the contaminants are decomposed or oxidized into other species. These species are either retained in the catalytic reactor or are removed by a subsequent post treatment process (i.e., reaction, adsorption, or absorption).

Present efforts include development of a base-line on existing high temperature catalysts as to their destruction of chemical warfare vapors and simulants and the development of candidate low temperature catalysts. The development of low temperature catalysts will be very important to catalytic oxidation being considered as a viable option to present CP systems. The low temperature catalysts will reduce the power requirements for this technology and the overall volume due to reduction of heat exchangers, etc.

ELECTRICAL DISCHARGE PLASMA

Air purification by electrical discharge plasmas is based upon the technology of conducting chemical reactions in an electrical environment. When neutral gas molecules become ionized by the action of a strong electrical field, an energetic electrically neutral media composed of atoms, free radicals, ions, and electrons are formed. The resultant energy transfer has the potential to change the vibrational and rotational states of toxic molecules leading to formations of smaller molecules. Several types of plasma electrical discharges have been addressed for CW agent destruction such as DC and AC corona, glow DC corona, microwave, AC silent discharge, and Radio Frequency.

HIGH PRESSURE FILTRATION

High pressure filtration is an air purification technique that is based upon the same technology as the current air filtration systems except that filtration occurs within a high pressure environment. High pressure filtration processes a large volume of contaminated air through a significantly reduced filter size than would be required for filtration at ambient pressure conditions. This particular filtration technique provides large air volumes in a rather small filtration canister. However, the drawback is that due to the reduced amount of filtration media and the corresponding reduced amount of contaminates that can be filtered, more frequent filter change-outs are required. This technology has specific application to airframe combat systems where filter volume is so critical that the present and potential advanced technologies may not be able to be designed small enough for the large airflow rates required.

ADVANCED FILTRATION DIRECTIONS

CRDEC as the U.S. Army lead laboratory in chemical defense is taking an aggressive approach in providing NBC CP to the military in order to provide the maximum protection while allowing the least degradation in performance in carrying out their mission during military conflict. In addition to pursuing alternate filtration technologies for combat systems while reducing certain disadvantages of the current system, CRDEC must keep in mind the logistic burdens of supply and demand during wartime. Therefore, the number of candidate technologies under investigation have been reduced so that current funds can be applied with more emphasis of select technologies. The following is the current plan in development of future filtration systems:

1. Develop high pressure filtration for airframe application.

2. Develop regenerative filtration technology for other combat systems for the near future (1990's).

3. Develop electrical discharge plasma for the far term timeframe (beyond 1990).

Chemical Defense - The Individual Protective Equipment - Collective Protection Interface

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The requirement to provide collective protection facilities to enhance the chemical warfare (CW) operating capability of military personnel at selected operational sites is now generally recognized. With this requirement has come the need to establish basic designs of collective protection facility and of the associated contamination control areas (CCA) through which personnel process during entry and exit.

In parallel with facility design has come the requirement to establish safe and practical ground operating procedures whereby personnel can enter, and subsequently exit the facility in the local presence of CW agents.

In the CW environment, collective protection use essentially involves the exposure of personnel to the potential hazards of a CW agent liquid and/or vapor presence during individual protective equipment (IPE) doffing and donning procedures. These potential hazards include:

(a) Direct liquid CW agent transfer to unprotected skin.
(b) Exposure of unprotected skin to vesicant agent vapor.
(c) Eye/respiratory tract exposure during respirator (mask) exchange procedures.

The general principles of the CCA design and function, as adopted for the USAF Survivable Collective Protection System (SCPS-2B) are illustrated in Figures 1 and 2. Figure 1 shows the general floor plan of the SCPS-2B facility with its 3 discrete areas; (1) the Toxic Free Area (TFA), (2) the Vapor Hazard Area (VHA), and (3) the Liquid Hazard Area (LHA). These 3 areas are sequentially flushed by a continuous input of CW filtered air, directed initially into the TFA, which maintains a slight overpressure in the facility relative to the external environment. Figure 2 shows, for each discrete part of the contamination control area of the facility, the specific actions which occur during the ingress of ground crew personnel. For each action area the potential local CW hazards to ingressing personnel are listed.

The extent of these potential hazards will depend on many factors, amongst which should be included the severity, type and duration of the local chemical agent challenge, and the relative number of ingressing personnel directly contaminated with liquid CW agent. In the latter respect, this potential hazard will depend upon the efficacy of liquid contaminant avoidance measures employed by personnel operating outside the collective protection facility during the attack and post-attack phases.

The meeting of the potential hazards to users of collective protection facilities and the need to maintain TFA integrity during and after personnel entry has dictated judicious attention to facility design and to the formulation of personnel entry and exit procedures. To a large extent, however, the satisfying of chemical safety requirements during facility entry and exit is dependent upon the meeting of specific individual protective equipment and procedural compatibility requirements at the protective equipment - collective protection interface. With few exceptions, current ground crew CW protective ensemble component design stems from the precollective protection era when no special recognition had to be given to the dictates of collective protection usage. In some instances the necessary retrospective formulation of don/doff procedures for this older-design equipment has precluded the achievement of optimum solutions to protective equipment - collective protection interface problems. This is particularly the case in relation to the vital operational need to minimize the times required for personnel to process into and out of the collective protection facility, a requirement secondary only to chemical safety considerations.

Figures 3 and 4 show a typical breakdown of the timing of individual don/doff actions which constitute the complete facility exit and entry procedures for ground crew. These typical times, recorded during USAFSAM SCPS-2B facility studies, were for individual subjects, but processing and assisting each other as buddy pairs. These timing breakdowns suggest some protective equipment - collective protection interface areas where potentially, significant reductions could be made in personnel exit-entry procedures timing, without prejudicing chemical safety. Of particular note is the marked difference between mean entry and exit timings, with exit time 84% greater than entry time. Typical subject times spent in don/doff activities in three specific areas of the facility are compared, for the entry and exit procedures, in Figure 5.

The VHA donning time, study mean 7.27 min, compares very unfavorably with the VHA doffing time, study mean 1.79 min. This difference is accounted for, in large measure, by the difficulty experienced by subjects in securing garment and boot fastenings, particularly when wearing Nuclear, Biological, and Chemical (NBC) glove assemblies. While aid by dedicated assistants in the VHA could reduce subject VHA donning times, the limited availability of assistants is likely to dictate their deployment in other areas of the facility CCA where attention to the prevention of liquid CW contaminant transfer to processing personnel is more vital. If this is the case, some advantages could accrue, in terms of easing and speeding up the VHA donning procedures, by further attention to the design of the fastenings of the fatigues/combat suit and boots.

The securing and fastening of the boot laces on the ground crew chemical protective overboot in the LHA during donning procedures is also difficult and time-consuming. The mean time to don these items (study mean 5.28 min) is 78% greater than mean doffing time (2.96 min), and the donning time represents approximately 24% of the subject's total facility egress time. Some design attention to the overboot fastenings could make a significant contribution to reducing donning, and possibly doffing times. One suggested approach, in which the conventional laces are replaced by hook-ended elastic (bungee) cords, is shown in Figure 6.

Under CW operating conditions the protective equipment - collective protection interface which constitutes the greatest potential hazard to ingressing personnel is the LHA changing chute area. Within the separate changing chutes, the potentially contaminated outer protective garments are removed from ingressing subjects. The local hazard to personnel at this interface comprises:

(a) The possibility of unprotected skin and/or undergarment contact by liquid chemical agent during the doffing of the outer protective garments.

(b) The unavoidable exposure of unprotected skin to the chemical agent vapor emanating, primarily from the protective garments, during the doffing procedures. This is of particular significance only in the presence of a vesicant agent challenge.

In relation to the limitation, or ideally the elimination of liquid agent transfer to subjects during their protective overgarment doffing procedures in the LHA changing chutes, a very strong case can be made for the deployment of dedicated shelter assistants to undertake these procedures. On the grounds of chemical safety, it is undesirable for undressing, ingressing personnel to handle either their own potentially contaminated outer protective garments or those of other personnel.

Studies undertaken at USAFSAM have shown a typical (mean) subject time of 4.65 min for protective overgarment doffing in the LHA changing chutes during facility entry, when subjects assisted each other in buddy pairs. The equivalent donning time during facility exit was 6.91 min. Each of these mean times includes approximately 2 min of the individual's time spent in assisting the buddy partner. The elimination of this buddy-assistance time by the provision of aid by dedicated assistants for the LHA changing chute procedures would, therefore, also markedly reduce the time spent by ingressing/egressing subjects in this specific area of the facility.

The employment of buddy-assistance techniques during ingress-egress procedures is attractive from the point of view of limiting the requirements for dedicated support personnel. This approach, however, is not conducive to the achievement of optimum flow rates of personnel into and out of the collective protection facility. In general, while the required timing for specific equipment don/doff actions is dictated by chemical safety considerations, the minimizing of this timing should be a priority target if operationally acceptable facility personnel shift change times are to be consistently achieved.

In considering the potential vesicant agent vapor hazard to personnel during their undressing/dressing procedures in the facility, the extent of the hazard is dictated by the magnitude of the local vesicant vapor concentration and the time of subject unprotected skin exposure. By special design measures, the local concentration of vesicant vapor in the changing chutes, to which undressing/dressing subjects are exposed, can be reduced; e.g., by chute flushing with clean or relatively clean air supplied direct from the TFA or VHA. The time of unprotected skin exposure, however, will be dictated by the type of chemical protective equipment worn, the necessary actions comprising the don/doff procedures, and the form and extent of assistance provided to the undressing/dressing subject.

Unprotected skin exposure is assumed from the first doffing action which breaks the protective integrity of the individual protective equipment assembly during facility entry, and prior to the establishment of assembly protective integrity during facility exit. On entry, for example, unprotected skin exposure will occur not only in the changing chutes but during the subject's subsequent passage to and through the VHA, prior to TFA entry. The need to minimize unprotected skin exposure time lends strong support to the employment of dedicated shelter assistants to expedite the personnel don/doff procedures which take place in the LHA changing chutes.

In terms of protective equipment - collective protection interface compatibility, the requirement to reduce unprotected skin exposure time to a minimum, in the presence of vesicant vapor, is more readily met by the protective undercoverall approach to below-the-neck CW protection. With this approach the doffing of contaminated outer garments, such as the fatigues suit (or aircrew coverall), can be completed without unprotected skin exposure. Such exposure occurs in this case only during the mask exchange procedures at the LHA/VHA interface and subsequent protective garment doffing in the reduced vapor hazard environment of the VHA. An additional advantage of the protective undercoverall approach is the reduced risk of liquid contaminant transfer to skin or personal underwear items which are protected by the undercoverall during outer garment removal.

An attempt has been made in this paper to highlight some of the factors to which attention could beneficially be paid to further enhance the chemical safety and operational acceptability of collective protection facility use in a CW environment. Some short term measures have been suggested which could further enhance chemical safety and significantly improve personnel ingress-egress times.

In the longer term, specific research attention given to collective protection requirements in the concept and design formulation stages of future individual protective equipment could be rewarding.

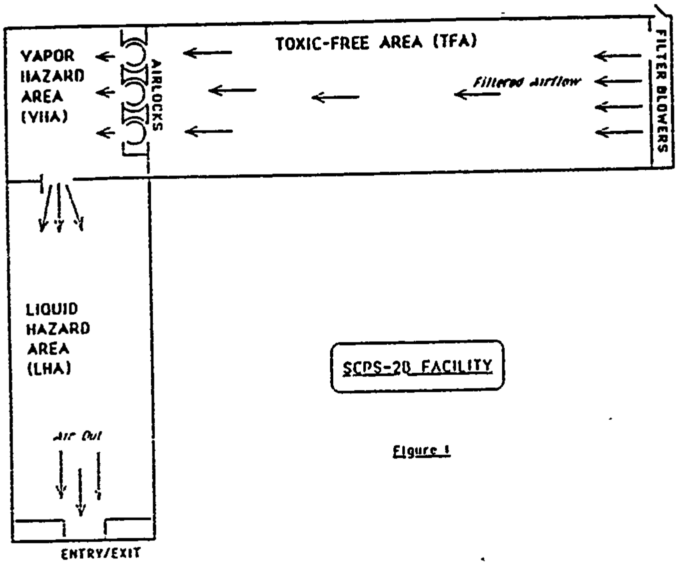
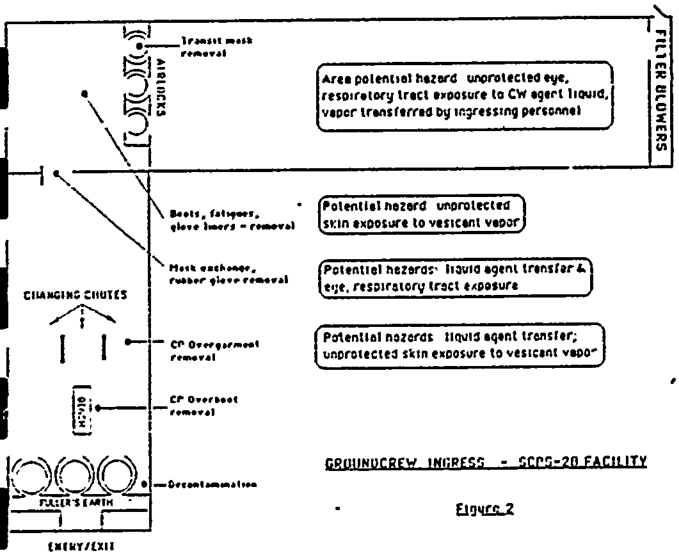


Figure 1



GROUNDCREW INGRESS - SCPS-20 FACILITY

Figure 2

EQUIPMENT DONNING (EXIT)

Mean Donning Time During Facility Exit:

Day	*min*
1	22.44
2	21.07
3	18.94
4	20.33
Mean:	*20.71*

Day 1 Timing Breakdown:

Area	*Procedures*	*min*
• VHA	Don fatigues, boots, gloves, overboots	7.27
• LHA	Mask exchange	2.21
• LHA Chute	Don prot. overgarment, secure hood	6.91
• LHA	Don chem. prot. overboots	5.28

Figure 3

EQUIPMENT DOFFING (ENTRY)

Mean Doffing Time During Facility Entry:

Day	min
1	13.14
2	11.85
3	10.29
4	9.81
Mean:	*11.27*

Day 1 Timing Breakdown:

Area	*Procedures*	*min*
• LHA	Doff chem. prot. overboots	2.96
• LHA Chute	Doff chem. prot. overgarment	4.65
• LHA	Mask exchange, doff rubber gloves	3.15
• VHA	Doff boots, fatigues, glove liners	1.79

Figure 4

DAY 1 DON/DOFF TIME COMPARISONS

Area	*Equipment / Procedure*	*Don Time*	*Doff Time*
VHA	Fatigues, boots, gloves	7.27	1.79
LHA Chute	Protective overgarment	6.91	4.65
LHA	Chem. prot. overboots	5.28	2.96

Figure 5

PICTURE OF OVERBOOT
(CONVENTIONAL LACES LEFT-ELASTIC CORDS RIGHT)

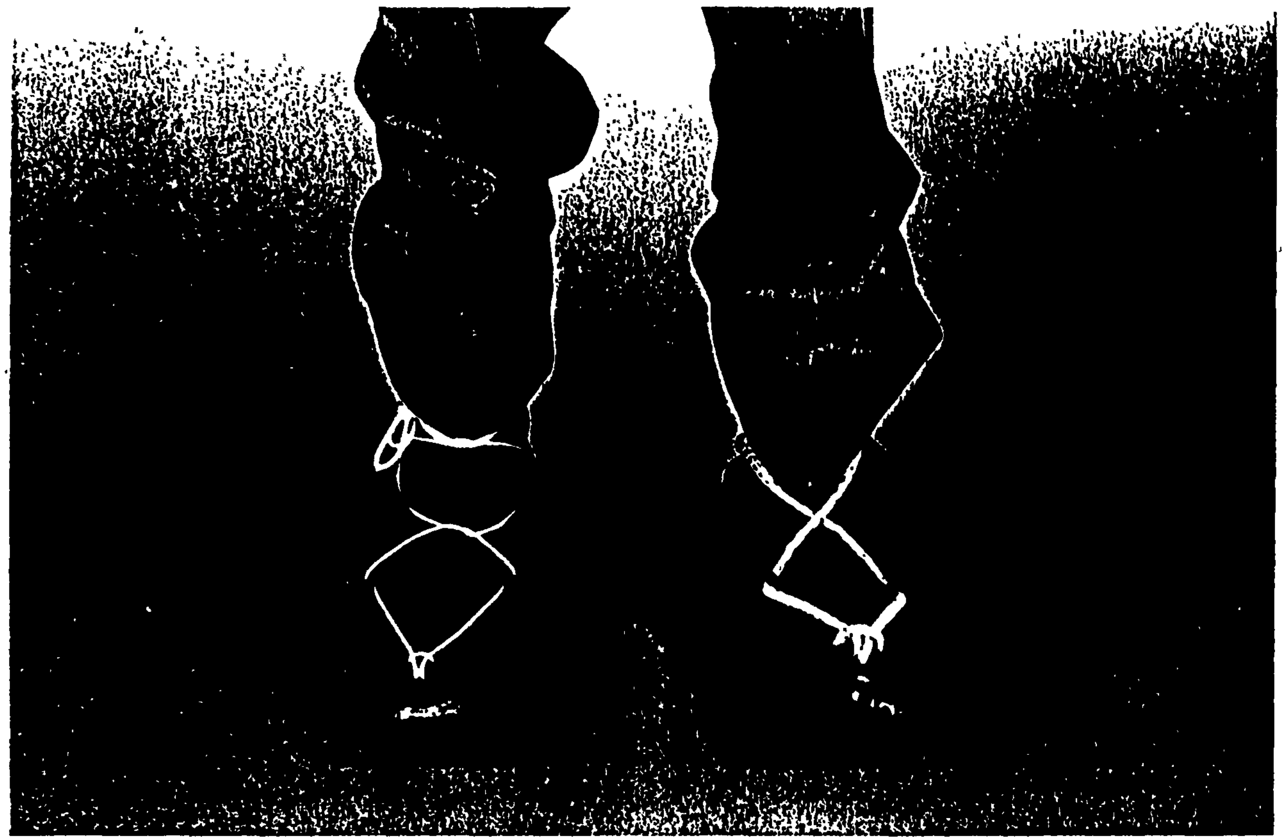


Figure 6

COMMAND AND CONTROL IN A CW ENVIRONMENT

Command and control of forces is a critical facet of mission accomplishment. With a chemical agent present, command and control becomes a vital aspect of survive to operate. In a chemical warfare environment, command and control must have a strong network for detection, identification and warning, a good system to analyze data and procedures for restoration of the base to 100% mission capable.

Detection, identification and warning in a timely manner requires:

- A data collection network, including detection instruments, casualty reports, wildlife indicators and UXO reports.

- Personnel trained in the effects of chemical agents.

- A system for dissemination of information.

In order to provide a proper analysis and estimated impact on base operations, the NBC representative in the SRC should be trained on agent affects and ATP-45.

To minimize the impact of the chemical attack and return the base to 100% mission capability each major staff agency must prepare contingency procedures and train personnel on those procedures.

- Deputy Commander for Operations focus on direct mission tasking, the requirements for mission planning and protection of aircrew as a priority resource.

- Deputy Commander for Maintenance is concerned with aircraft protection and preparation of aircraft for mission tasking.

- Deputy Commander for Resource Management is responsible for procurement of resources and material to support aircraft buildings for mission tasking.

- The Base Commander is tasked with the restoration/maintenance of the base/airfield in a combat capable status.

The system culminates with the Wing Commander, the risk taker, who weighs the situation and establishes priorities and takes the risks necessary to ensure the wing meets its mission tasking.

1Lt Morrison/50CSG/DW/450-6207

1Lt Charles E. Morrison, USAF, 317-56-1442

Lieutenant Morrison entered the United States Army in July 1970. His Army assignments include a combat tour with the 101st Airborne Division, Vietnam; NCOIC Personnel Readiness, Headquarters VII Corps, Germany and Chief Ambulance Service, Ft Campbell, Kentucky. He left the Army in June 1980 to complete his college degree.

In September 1983 Lieutenant Morrison was commissioned into the United States Air Force. He has served as the Chief, Disaster Preparedness, 44th Combat Support Group, Ellsworth AFB, South Dakota and his current assignment as Asst Chief, Disaster Preparedness, 50th Tactical Fighter Wing, Hahn AB, Germany.

Lieutenant Morrison has a bachelor ot Science degree in Geography. His military awards include the Air Force Commendation Medal, the Army Commendation Medal and the American Defense Preparedness ROTC award.

GERMAN C-DETECTION FLUORESCENCE MONITOR

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Federal Republic of Germany

The paper results from a research program conducted at Battelle Frankfurt during the past several years with the objective to develop new techniques for the detection and survey of Chemical Warfare Agents based on the use of fluorescence.
These investigations were stimulated by the present needs of the military for reliable techniques that are capable of surveying surfaces for the presence of deposited warefare agents in a time period as soon as possible.
In this context " SURVEY " means primarily a yes/no statement as to wether or not a surface is contaminated. The scope includes :

- o SURVEY OF EQUIPMENT (e.g.aircraft)
- o SURVEY OF PERSONNEL

for decision on decontamination necessity and success.

Under contract of the German Ministry of Defense, Battelle currently is developing a portable C-Detection Fluorescence Monitor, designed as a back-pack version.

Introduction

The work described below is concerned with the development of a Fluorescence Sensor System for detecting chemical warfare agents on different surfaces. The principle of operation of the sensor involves pretreatment of a surface with a liquid reagent spray that reacts selectively with chemical agents to form products that are highly fluorescent when exposed to ultralviolett light.

Chemistry

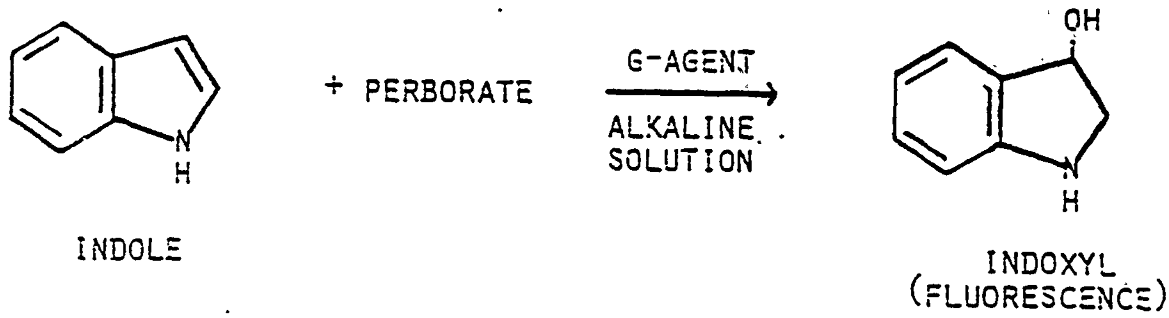
Reagents for the detection of nerve agents(Schoenemann solution) and H-mustard agent(Dye adduct solution) were developed under different contracts sponsored by the German Minsitry of Defense and the US Air Force.

The Schoenemnann approach involves treating an agent contaminated surface with an indole-peroxide reagent, and then exciting fluorescence from the reaction products. Fluorescence from the Schoenemann reaction products is much stronger than that from the agents themselves facilitating their detection. Normally the Schoenemann flourescence approach is employed only with G-agents and is not used for the detection of VX or H-type agents.

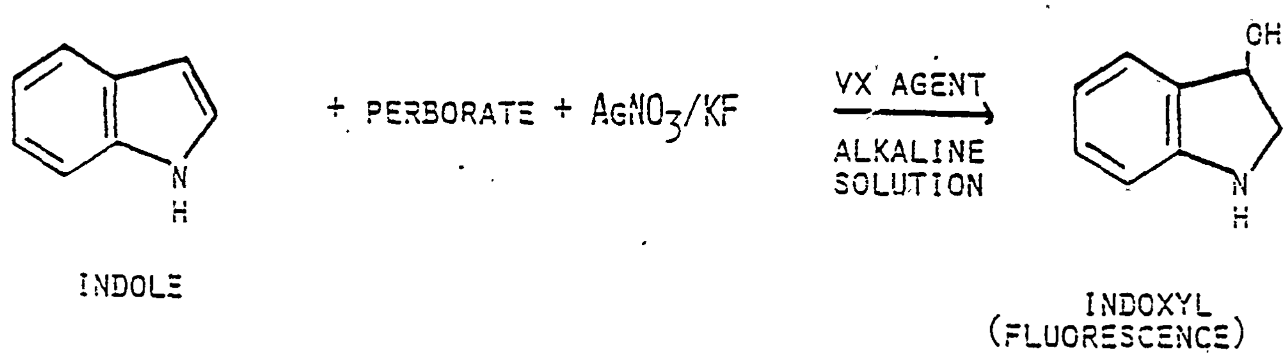
We developed an optimized Schoenmann approach for the G-agents and a modified Schoenmann approach based on the use of an AgNO3/Kf activator for VX. An attempt to develop a 5 step reaction scheme to convert H-agents to G like agents was unsuccessful, however, a fluorescent dye adduct technique was found using several different triphenyl methine dyes of which Brilliant Blue R gave the highest sensitivity.

The reactions involved in the pretreatment chemistry for the three types of agents are summarized in Figure 1.

G-AGENTS (SCHOENEMANN REACTION)



VX AGENT (MODIFIED SCHOENEMANN REACTION)



H-MUSTARD AGENTS

$Cl-(CH_2)_2-S-(CH_2)_2-Cl$ + BRILLIANT BLUE R ⟶ FLUORESCENT ADDUCT

MUSTARD

FIGURE 1 : PRETREATMENT CHEMISTRY DEVELOPED FOR AGENT DETECTION BY FLUORESCENCE

Tests with the chemical warfare agents GB,GD and VX were performed at the NBC Proving Grounds in Munster, West Germany.

Detection of G-Agents

Performance tests on selected surface samples contaminated with GD and GB showed, that freshly contaminated substrates such as concrete, asphalt, sand and grass permit satisfactory detection of the two agents without serious interference effects. The agent densities varied from 2 to 5 g/m. On asphalt, the highly volatile GB was detected by a pronounced signaleven after four hours. The less volatile GD was still detectable on all substrates investigated (concrete,asphalt and grass) after two hours (Figure 2 and3).

Detection of VX-Agents

Tests with VX showed that immediately after reaction with an activator very high fluorescence intensities and short response times (comparable to the GB values) are achieved (Figure 4).

Detection of H-Mustard

The method developed for the fluorescence detection of mustard agents is based on colorometric indicator reactions, which can generate fluorescing dye adducts. After first successful results with Michler's Ketone it was decided to screen various dyes to find one with a high fluorescence intensity when mixed with mustard. A total of 38 dyes was screened. Of the triphenyl methine dyes Brilliant Blue R was found to give the highest fluorescence. An adduct fluorescence spectrum for mustard with Brilliant Blue R is given in Figure 5. The Brilliant Blue R is used in an 0.02% solution containing 70% water and 30% ethanol. Performance tests on overgarment material contaminated with HD showed a realtively high fluorescence intensity combined with a very short response time (half maximum intensity < 0.5s ; Figure 6).

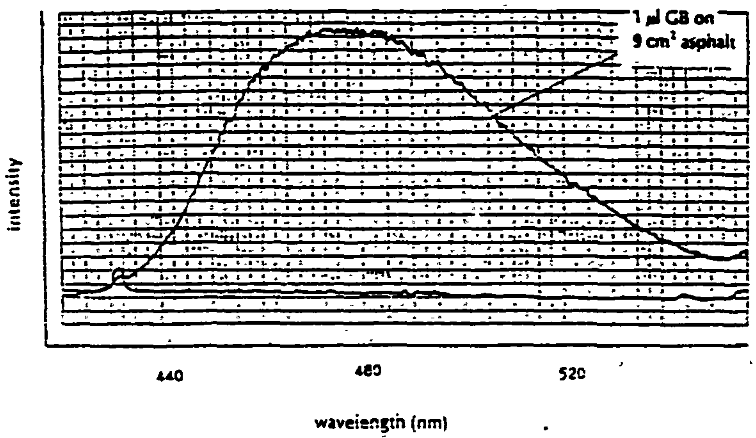


FIGURE 2: DETECTION OF GB-DROPLETS ON ASPHALT

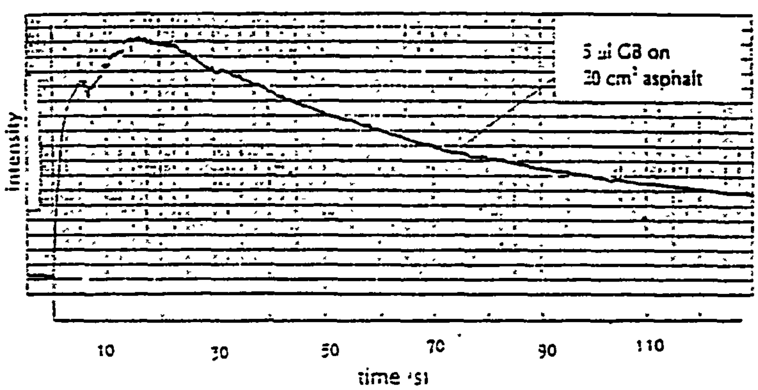


FIGURE 3: TIME DEPENDANCE OF THE FLUORESCENCE INTENSITY OF GB DROPLETS ON ASPHALT

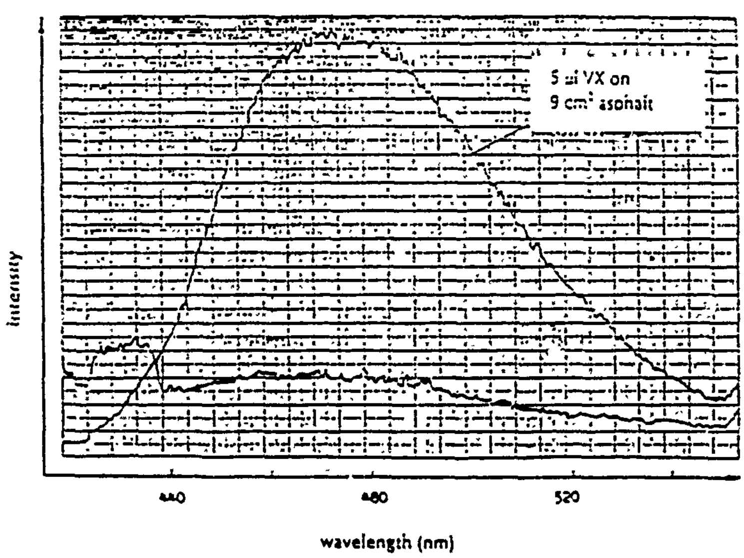


FIGURE 4: DETECTION OF VX DROPLETS ON ASPHALT WITH PRIOR REACTION OF $AgNO_3$

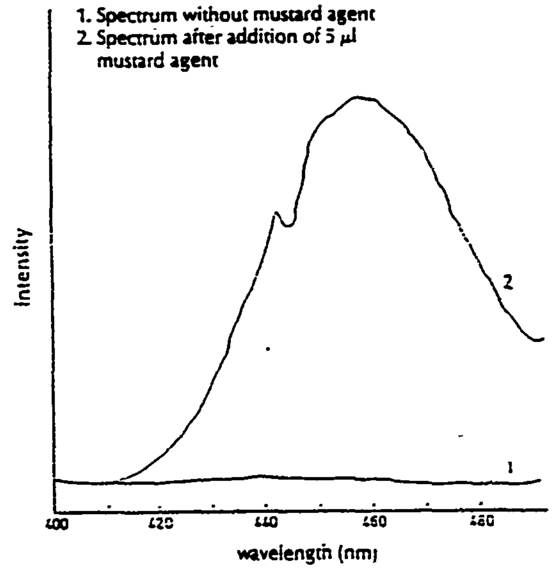


FIGURE 5: FLUORESCENCE SPECTRUM EXCITED AT 360 NM WITH BRILLIANT BLUE R

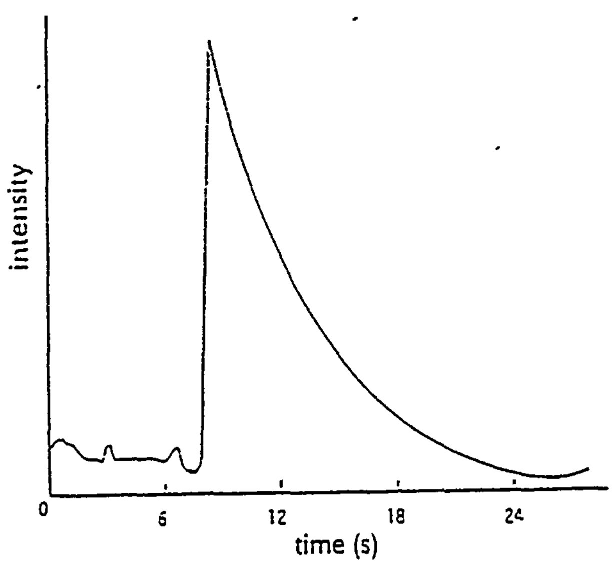


FIGURE 6: TIME RESPONSE FOR FLUORESCENCE FROM 30uL HD ON OVERGARMENT MATERIAL

Conclusions for Applications

Concerning the practical applications of the fluorescence technique, the following features are most important:

- The nerve agents GB,GD,VX and the blister agent H-mustard can be detected with high sensitivity utilizing the fluorescence technique

- The rise time of the fluorescence intensity is fast enough for scanning military equipment, aircrafts, personnel etc. within a convenient detection time

- There is in principle a slight fluorescence interference from specific substances like motor oil. However, this interference can be made negligible by well known technical means e.g. suitable selection of filter passband,differential processing, lock-in technique etc.

Development of Hardware

Battelle is currently working on a contract for the German Ministry of Defence with the objective to develop a portable prototype device for rapid detection of chemical warfare agents using the described method. This instrument will be used to demonstrate the applicability of the technique for personnel and equipment contamination detection.
The C-Detection Fluorescence Monitor is designed as a back-pack version (Figure 7).

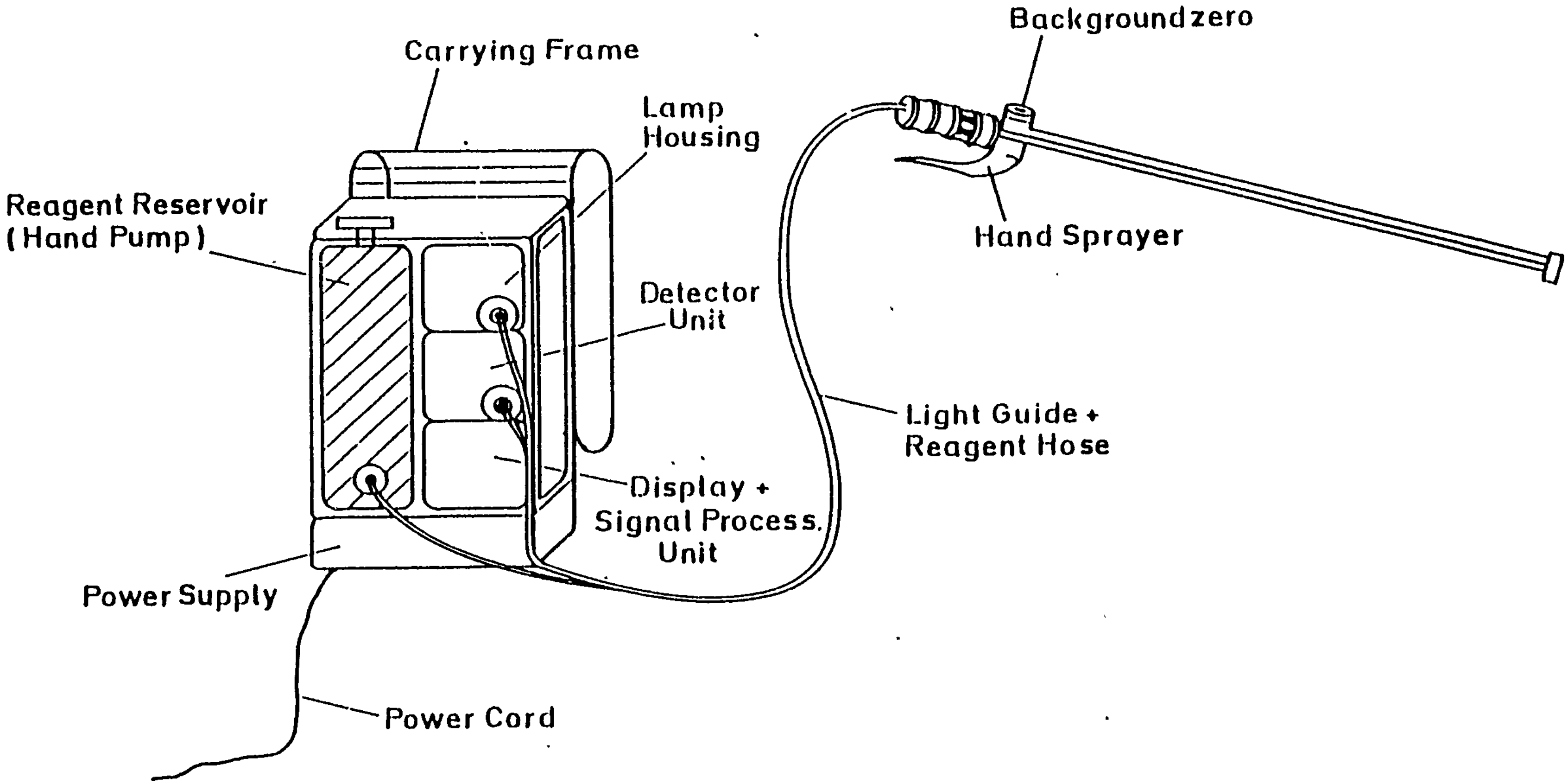


FIGURE 7: PORTABLE C-DETECTION FLUORESCENCE MONITOR (BACK-PACK VERSION)

It consists of three subunits :

- o Reagent Tank
- o Electronics Module (inc.Power supplies)
- o Sensor Rod

The Reagent Tank and the Electronics Module are mounted at the carrying frame. The Electronics Module covers the Lamp Housing, the Detector Unit, the Signal Processing Unit, the Display Unit as well as the Power Supplies. A common plastics light guide is used for guiding of excitation and detection light. All supply cables like the light guide, reagent hose and electric cords are linked into a handheld Sensor Rod (Figures 8 + 9).
The Sensor Rod covers a handsprayer for application of the reagent fog and a key for activation of the electronic background surpression circuit.
In operation the soldier wears the carrying frame on his back and the sensor rod in one hand. For detection the procedure is as follows:

- o Home in on the area of interest
- o Press down the Backgroundzero key
- o Activate the Spray gun

If a preselected threshold value is exceeded, alarm is indicated optically(lamp) and acoustically(buzzer).
In this preliminary version the complete system will have a weight of approximately 15 kp. For the next development step considerable weight reduction is planned by using a battery powered flashlamp.

The C-Detection Fluorescence Monitor will be available for testing in approximately 2 months.

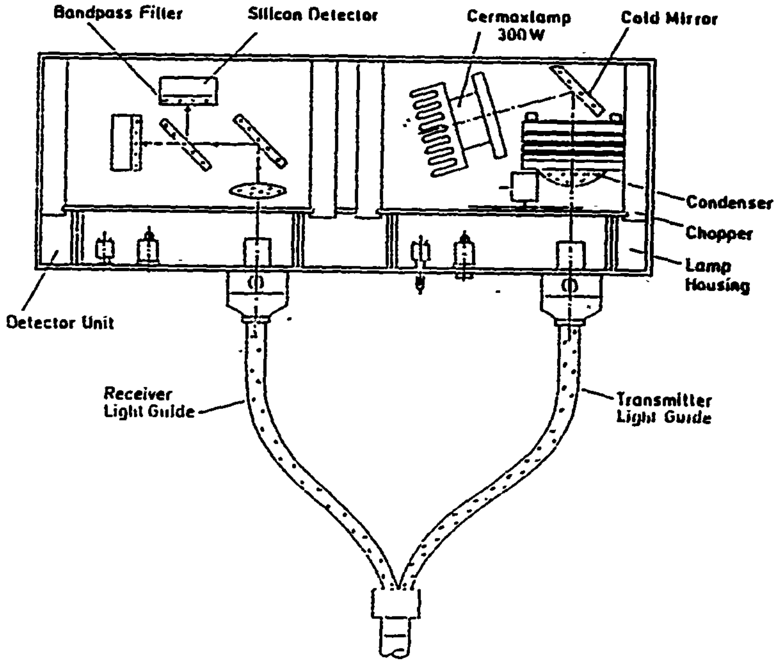


FIGURE 8: LAMP HOUSING AND DETECTOR UNIT

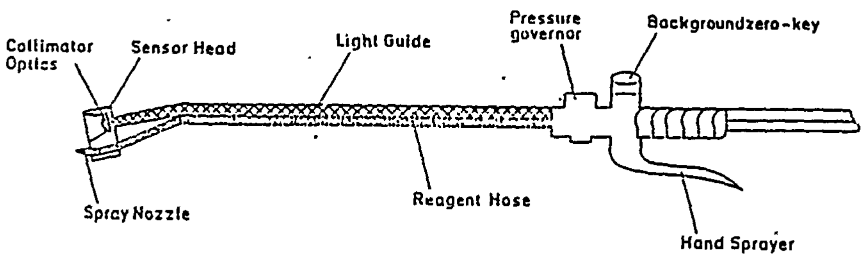


FIGURE 9: SENSOR ROD

THE USE OF CAM ON AIRBASES

Dr. JOHN T. BARTLETT and MR. DAVID A. BLYTH

The instrument is a hand-held device, completely self-contained and weighs about four pounds. The lithium sulphur dioxide battery will last for approximately 16 hours at room temperature and approximately two hours at -25°C. Supplied with the instrument is a confidence tester (a source of simulant vapour for both nerve agent and mustard agent mode) and a number of inlet filters whose only function is to prevent the ingress of excessive amounts of dust.

The principle of operation is ion mobility spectrometry, in which the incoming air is ionized as it passes over a 10 mc Ni63 source. [This very low energy β source provides no radiation hazard]. The type of ion produced e.g., small air ions or larger organic vapour ions, is identified by measuring its time of flight across a known path length in a controlled electric field. The number of ions produced is related to the vapour concentration, hence CAM is able to quantitatively and qualitatively identify the sample vapour, provided it has been previously programmed to seek out the appropriate ion flight times. Upon receipt of a vapour that it has been programmed to recognize, the identity and concentration of vapour is fed to an on-board computer in whose memory the toxicity of that particular agent is held. The 'hazard' to the operator is then calculated and displayed.

The form of display has been the subject of much discussion with all Branches of the Armed Forces. The format chosen was an eight-bar display, the number of bars illuminated indicating the extent of the hazard [as opposed to the identity of th agent and its concentration]. The instrument and its performance goals can be summarized in the following two Tables :

Table 1

The Instrument

1. Held and operated by one hand;
2. Completely self-contained;
3. Weighs under 2 Kg;
4. Battery life approximately 16 hours;
5. Cost allows large-scale of issue.

Table 2

CAM Performance

1. Indicates the presence of chemical agent vapour;
2. Indicates the magnitude of the hazard to the operator;
3. Has a realistic sensitivity;
4. Responds and clears in a few seconds;
5. Can be programmed to detect harmless simulants;
6. Could identify the chemical agent.

In the light of the experience gained in many Trials and Exercises, only Item 4 of Table 2 needs qualifying. Whilst the instrument will respond very quickly, its clear-down time has been found to be dependant upon the quantity of vapour ingested. In most cases, however, prolonged clear-down times can be avoided by suitable operating procedures.

The acceptance of CAM into service and its use by servicemen in the field has high-lighted a gap in our training schedule. CAM, or for that matter any similar equipment, cannot fulfil its intended role unless the operator has some practical knowledge of the behaviour of vapours in the open air, i.e. the knowledge of the 'art of vapour sampling'. The first lesson to be learnt is that vapours do not obey the laws of radiation [often assumed because CAM is associated with radiation monitors]. Other lessons - not always obvious to the uninitiated, include the absorption of vapour on to surfaces, including detector inlets and the fact that vapour can collect in 'pockets'. Practice in operating CAM soon helps to create an understanding in the behaviour of vapours and, in addition, gives a knowledge of any false alarms that may be encountered in the operators environment. This latter consideration is particularly important in some enclosed areas such as machinery spaces or vehicular maintenance areas, where solvents or cleaning materials may be used and produce a small reading on the CAM display. With prior knowledge, such background readings need pose no problems when monitoring. It should also be remembered that CAM will only detect vapour and is, therefore, not effective in indicating a contact hazard from liquid contamination. This consideration becomes important in cold temperatures due to the lowering of the agents vapour pressure.

As mentioned previously, the instrument has to be programmed with the necessary agent parameters before it can detect that vapour. Whilst this programming is readily achieved, the question of detecting unknown agents has to be answered. In the CAM display, three small dots appear (with no bars) if the instrument is sampling a vapour which produces ions it cannot recognise. The usefulness of this system is still a matter of debate, since many harmless vapours, such as diesel engine exhaust, can also give a three dot display. The problem really raises the old question, should a detector be very specific with no false alarms, or be capable of detecting unidentified vapours with a high false alarm risk? Realistic training may be the best answer.

CAM has been found to be particularly useful in Air Base operations, especially when monitoring personnel entering collective protection, such as crew briefing facilities and medical rooms. It is, of course, ideally suited for monitoring contaminated aircraft and equipment and for checking the efficiency of decontamination procedures, but if used in a more general reconnaissance role, its use may be restricted because it becomes saturated at high vapour concentrations.

Remote Detection of Chemical Agents by IR-Lidar

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1. Introduction

There is an urgent need for a device that allows the remote detection and localization, identification and quantification of chemical agents in the atmosphere. The instrument should provide the capability to carry out measurements over distances on the order of a few kilometers, to allow a survey of larger areas from a central location. A high sensitivity to chemical agents is mandatory, to allow their detection at concentration levels that are well below lethal values. At the same time, the instrument must be insensitive to the presence of other species in the atmosphere to avoid false alarms. Measurements need to be performed at day- and night time and should be independent of weather conditions.

A multispectral CO_2-laser radar (also called lidar for <u>light</u> ra<u>dar</u>) operating in the infrared spectral region (9 - 11 µm) is well suited for this task. It actively probes the spectral features of the atmosphere at various selected IR-wavelengths to yield specific absorption patterns when chemical agents are present.

Appropriate instrumentation is under development in Germany since the early 1970's. Goal is the design of a simple and reliable instrument with the option to allow autonomous, automated operation. This paper summarizes the measurement principles, the basic instrument design and the status of the hardware development of these efforts.

2. Measurement Principle

2.1 Differential Absorption Spectroscopy DAS

The measurement principle is based on the Differential Absorption Spectroscopy (DAS-) method: most molecules show more or less narrow absorption bands in the infrared spectral region, that are unique for each species and thus can be used to detect their presence and also indicates their concentration.

Fig. 1 shows absorption spectra for GD (Soman) and GB (Sarin) that were measured with a CO_2-laser in the 9 - 11 µm spectral region[1]. It is quite noticeable that the absorption coefficient of these species varies quite considerable between nearby CO_2-emission lines. For example, the relative absorption of GB (Soman) between the 9P(10) and the 9P(40)-CO_2-lines at 9.473 µm and at 9.733 µm is as large as $1 \cdot 10^{-3}$ m^2/mg. Thus the observation of the relative extinction of CO_2-laser radiation between different selected emission lines yields an indication, whether a species with the appropriate absorption features is present or not.

Problems arise from the presence of absorption lines from other species in the atmosphere. Interference from these absorption features can cause an obscurance of the observed spectral characteristics or can cause a false alarm, when similar spectral featuers are encountered as the observed ones. These interference problems can be avoided when a larger number wavelengths are observed to deduce unique spectral features. Present studies indicate that about 10 line pairs are sufficient to yield species sensitive detection probabilities.

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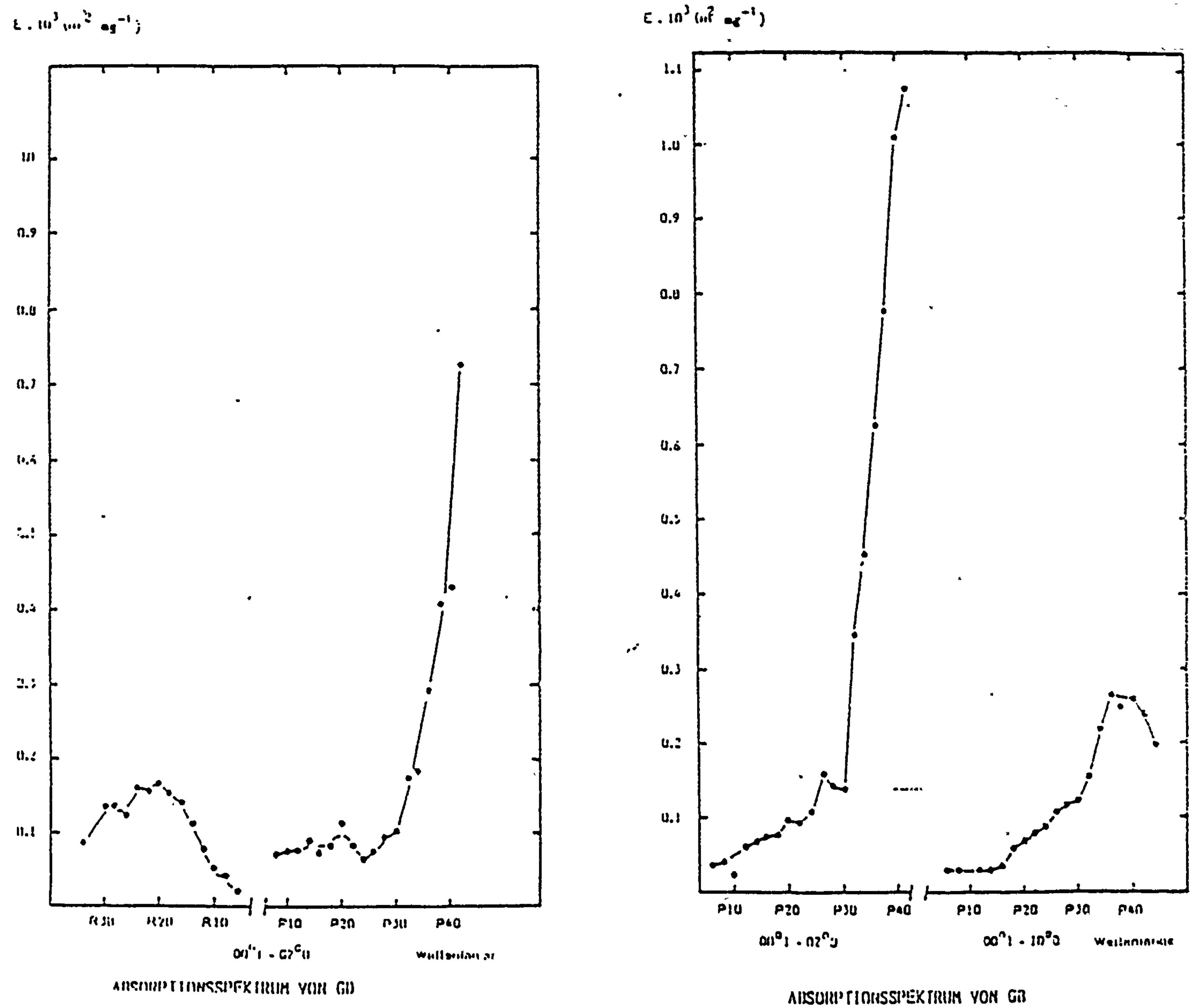
[1] Dr. Staginus, Wehrwissenschaftliche Dienststelle der Bundeswehr, Munster, FRG, private communication



<u>Fig. 1:</u> Absorption cross sections for various CO_2-lines in the 9- and 10-µm bands for GD (Soman) and GB (Sarin) /1/

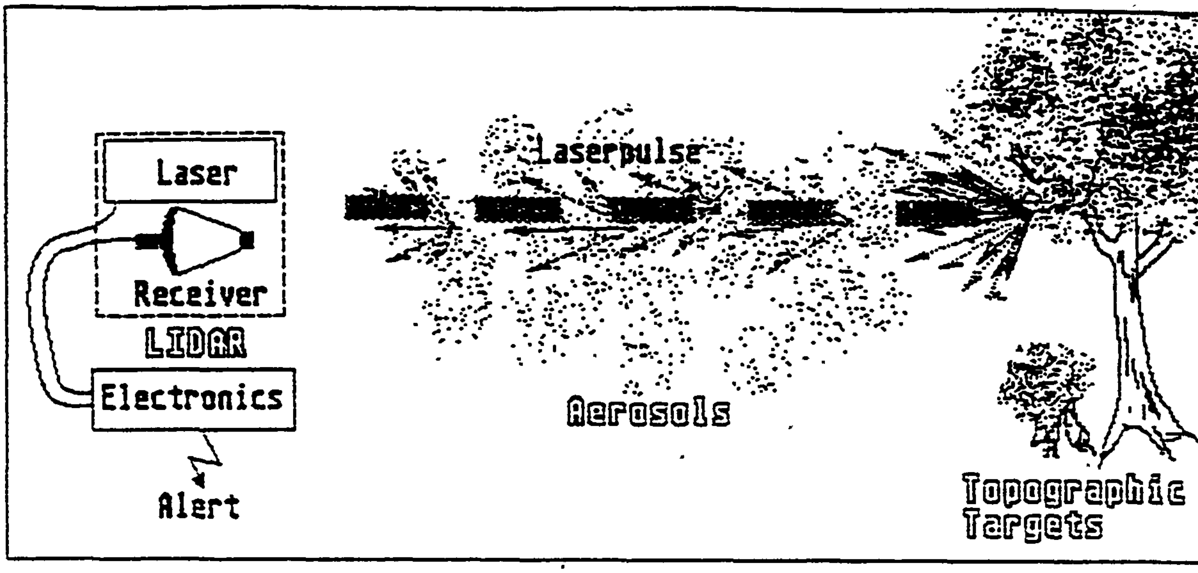


Fig. 2: Schematic lidar instrument with aerosols and topographic targets as backscatterer

2.2 Lidar Principle

Fig. 2 shows the basic layout of a lidar instrument (lidar = Light Detection And Ranging, the optical equivalent to a radar): a laser transmits a short light pulse into the atmosphere. A small fraction of the light is returned to the receiver telescope of the lidar by either non-cooperative topographical target like trees, bushes, buildings etc., by aerosol clouds formed by natural or artificial fog, or by naturally occuring background aerosols.

The distance between the lidar instrument and the target is determined by a time-of-flight measurement of the signal. The intensity of the received signal is dependent on instrument parameters like power of the pulse, diameter of the receiving telescope, sensitivity of the signal detector etc., on the target properties, either the reflectivity of solid targets or the backscatter coefficient of aerosols, and finally on the atmospheric extinction between lidar instrument and target.

Of these parameters, only the atmospheric extinction varies rapidly with the wavelength due to the narrow absorption features of atmospheric species, while the instrument parameters and target properties show only little dependence on the wavelength. Thus, to perform the DAS-measurement with a lidar, the influence of instrument parameters and target properties are eliminated by taking the ratio of the intensities measured at nearby wavelengths. This measurement principle is also termed DIAL for Differential Absorption Lidar.

Various measurement modes of lidar instruments are feasible according to the different targets used. With topographic targets, the average concentration along the line of sight can be obtained from the lidar measurement. By scanning the lidar to various targets around its location, a larger area can be surveyed to indicate the presence of chemical agents in the surveyed regions.

When aerosol backscatter is used as target, the distance to the chemical agent cloud can be measured as well. Thus, a combination of a scanning lidar with the ability to use aerosol backscatter as target allows to obtain 3D-maps of c-agent concentrations around the measurement site.

Another measurement capability of lidar instruments may be the recognition of various types of aerosol clouds and to determine those aerosol clouds that contain chemical agents. However, these DISC (Differential Scattering)-measurements are just in the initial research phase and the science base is just being established.

Lidar measurements using topographic targets are easiest to perform, since their reflectivity is comparatively large and the measurement signal accordingly rather large. Backscatter from natural aerosols is smaller by a factor of about 100, so the lidar performance needs to upgraded. However, aerosol clouds can have much larger backscatter coefficient and can yield accurate measurements with less powerful lidar instruments.

The advantage of DIAL-measurements compared to other passive methods like Fourier-transform spectrometers or double-ended laser absorption spectrometers is the independece on atmospheric- and illumination-conditions, and the capability to survey a large area by scanning the instrument. When aerosol backscatter is used to return the light, even 3D- maps of chemical agent clouds can be obtained.

3. Basic Instrument Design

As discussed above, the atmospheric extinction between two wavelengths is probed by emitting two laser pulses that are reflected by the same target under identical conditions. However, the target itself as well as the atmosphere between lidar instrument and target vary with time (scintillations, movement of leaves and trees, drift of aerosol clouds, etc.). To achieve sensitive extinction measurements, the probe pulse must be transmitted during such a small time interval that the atmosphere is essentially 'frozen'.

Measurements indicate that the atmosphere is frozen for time intervals below approximately 3-10 ms (atmospheric correlation time), dependent on the atmospheric conditions and on the target[2]. This means for the design of a DIAL-instrument that it requires the capability to emit pulses with a different wave-

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[2] N. Menyuk, D. K. Killinger:
Temporal correlation measurements of pulsed dual CO_2 lidar returns
Opt.Lett. 6 (1981) 301-303

lengths within a time interval of about 3 ms.

About ten wavelength pairs may be required for the detection and identification of chemical agents in the presence of other atmospheric gases. However, these various line pairs do not have to be probed during the atmospheric correlation time, as long as the individual measurements are used to determine the atmospheric extinction between these wavelengths. The different line pairs must be probed sufficiently fast, so that a 'typical' cloud within the optical path remains stationary. This time is estimated to be about 1 s.

Thus a basic requirement for a c-agent lidar is, that it has the capability to probe wavelength-pairs within the atmospheric correlation time (about 3 ms), and to determine the atmospheric extinction between up to 10 frequency pairs within 1 s. A special tuning device is required to allow fast wavelength switching between two preselected wavelengths, and to allow a 'random access' selection of up to 10 wavelength-pairs within 1 s.

At the same time, stringent requirements have to be met with respect to the pointing stability and the mode shape of the laser. Since topographic targets and aerosol clouds can be highly non-uniform, small deviations of the beam pointing or the transverse mode shape can cause large variations of the target reflectivity and thus can introduce significant errors in the extinction measurement. Thus the mode wander must be much less than the intrinsic beam divergence of the laser beam.

Two basic approaches exist for the rapid frequency switching of the lidar:

- two independtly tuned lasers with medium pulse repetition frequency PRF (about 20..50 Hz),
- a single laser with high PRF (300 Hz or more) and a rapid tuning device for wavelength switching.

Both solutions have specific pro's and con's[3]. Mainly on grounds of more compact design and simpler control of the beam wander, we have selected a lidar design with a single high PRF-laser.

4. Development Status in Germany

Presently a frequency-agile lidar with the name MIRACL (for Multispectral IR-Absorption CO_2-Lidar) is under development at the Battelle-Institut in Frankfurt. This lidar is designed as a test bed for some future operational instrument. One design goal is to build a simple instrument with good reliability, that allows to perform the required proof-of-concept measurements, but that gives also insight into the problems of autonomous, automated operation.

Fig. 3 shows a schematic drawing of the MIRACL-instrument: The largest component of the lidar-head is the high-PRF CO_2-laser. A commercial item from Laser Science, Inc. was selected for this test bed, that can be operated with a PRF of 300 Hz. In the laboratory, however, the laser has already been operated with up to 500 Hz.

This laser provides a pulse energy of 200 mJ on strong CO_2-lines, and about 50 mJ on the weak lines. This power is sufficient for measurements over a 2-km-path, using topographic targets as

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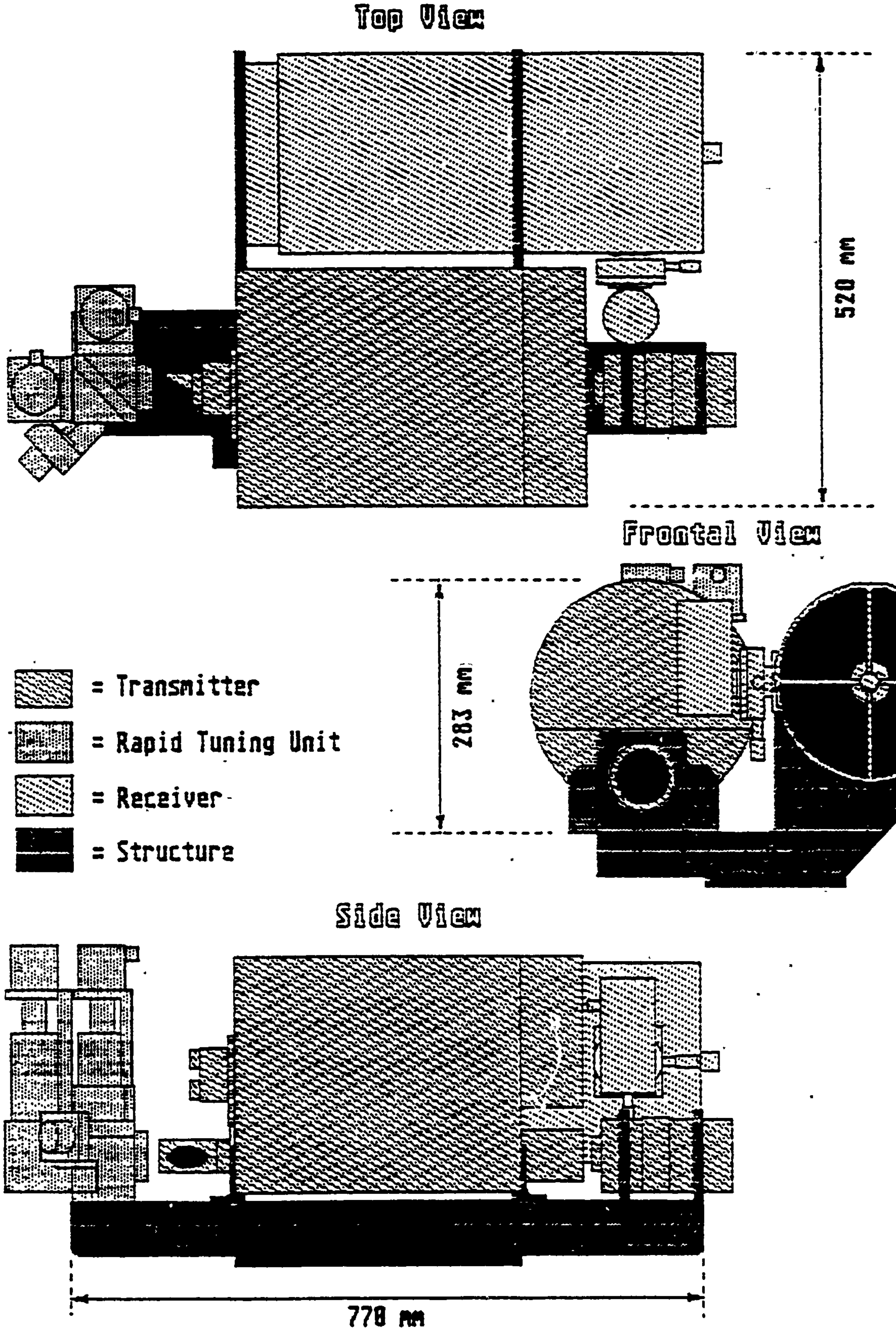
[3] M. Endemann, E. Golusda, E. Hansen, H. Hoeffgen: Entwicklungsarbeit zur Beseitigung von Querempfindlichkeiten bei der Ferndetektion von chemischen Kampfstoffen mit einem multispektralen CO_2-Laser-Lidar-System
Endbericht für Vertrag Nr. E/B31E/E0134/D5263, Battelle-Bericht R-66.079-6 (1986)



MIRACL (Multispectral IR-Absorption CO_2-Lidar)

Fig. 3: Schematic view of the MIRACL-instrument

reflector. Measurements over longer paths or using aerosol backscatter can be made, but longer averaging times are required.

The receiving telescope has a diameter of 20 cm and is rigidly mounted onto the laser resonator. It focusses the light onto a LN-cooled HgCdTe-detector with low-noise preamplifier.

The most critical component of MIRACL is the rapid tuning unit, which is mounted behind the laser head. It provides the frequency switching within a time of less than 3 ms, and can tune to 10 different line pairs within one second, including 5-pulse averages at each line pair.

The rapid tuning unit is shown in Fig. 4. It comprises two grating units that are independtly controlled by high-resolution

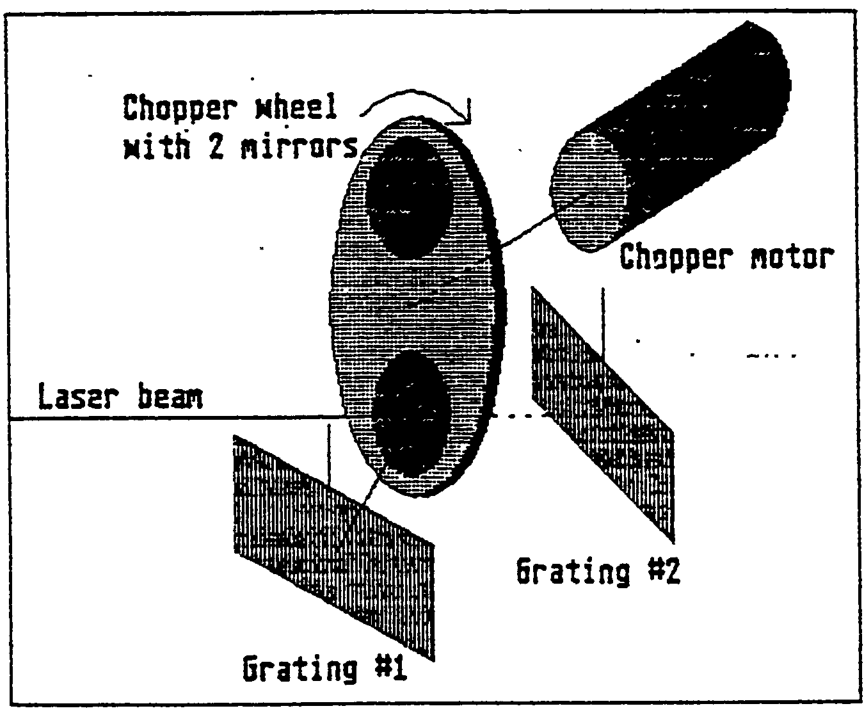


Fig. 4: Schematic view of the rapid tuning unit. A rotating 'chopper mirror' intersects the optical axis of the laser resonator and alternately switches in one of two gratings for wavelength-selection.

stepper motors (50,000 steps per revolution). The large number of steps allows to set the grating angles directly with the motors, without need for an extra transmission. Special custom-designed damping units are required to increaase the settling time from up to 100 ms to less than 10 ms.

The rapid switching between two wavelengths is done by a 'chopper mirror'. This mirror rotates around a 45°-axis between the two grating units, which are mounted with a 90°-angle to each other. The chopper-mirror switches between the two independently set gratings, either by reflecting the laser resonator onto the one grating, or by transmitting the light to the other grating.

The mechanical design of the rapid tuning unit is rather simple and without stringent tolerances. Thus it is reliable in operation and easy to maintain. In its second version it is designed in such a way, that is can be completely dust shielded, so that long lifetimes of the optical components can be expected.

5. Conclusions

A multispectral lidar instrument has the capability to detect and localize chemical agents in the atmosphere over distances of a few kilometers. The German MIRACL-lidar is on its way to demonstrate the measurement capabilities of such an instrument in field measurement campaigns by the end of this year.

Present experience indicates that reliable operation of the various lidar-components can be expected, although some 'teething-troubles' are still present. Technological advances in laser design and electronics make the automated operation of such an instrument feasible, but further component development is still required, mainly in the area of long-lifetime laser sources and associated equipment.

DISC/DIAL TECHNOLOGY

FOR

CB DETECTION

BY

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ABSTRACT

The U.S. Army Chemical Research, Development and Engineering Center (CRDEC) is currently engaged in an extensive multi-year exploratory development program to exploit laser radar for CB Stand-Off Detection. At present, the only near term capability for the detection of chemical agents at a distance is the use of passive infrared sensors. These sensors can detect only chemical vapors. Active (laser) infrared (IR) systems employing Differential Scattering and Absorption Lidar (DISC/DIAL) are being developed for the detection of chemical agents in all physical forms: vapor, aerosols, and rains, as well as liquid surface contamination. In addition, an ultraviolet (UV) system employing laser induced fluorescence is being developed for the detection of biological agent clouds consisting of pathogens and toxins.

The principles of operation of these systems and the history of their development will be briefly discussed. The IR and UV breadboard systems have recently participated in an extensive field test employing battlefield concentration of simulants and interferents with excellent results. These data will be discussed along with the necessary development efforts required to adapt the DISC/DIAL technology to Airbase Defense and attack recovery.

The U.S. Army Chemical Research, Development and Engineering Center (CRDEC) is currently engaged in an extensive multi-year exploratory development program to exploit laser radar for CB Stand-Off Detection. The objective of this paper is to discuss the current status of the IR DISC/DIAL program for chemical detection and the Ultraviolet Laser Induced Fluorescence (UV LIF) program for Biological/Toxin detection.

The Army is making significant investment in Stand-Off technology because it is the only technology known that can support the doctrine of contamination avoidance. By providing rapid wide area surveillance, early warning of the threat, and by being easy to set-up and move, the stand-off detection increases defense capability while reducing total number of alarms required.

At CRDEC there are three phases to our Stand-Off Detection program; the XM21 Passive Remote Sensing Chemical Agent Alarm; the Laser Radar (LIDAR) CB Stand-Off Detection System; and, for the future, integration of these technologies with other electro-optic systems in integrated sensor suites.

First we will focus on the chemical detection portion of the laser radar project called IR DISC/DIAL. The objective of this project is to provide chemical laser Stand-Off detection systems for CBW defense applications. The systems capabilities are to:

- Scan surrounding atmospheres and terrains
- Operate in fixed or mobile mode
- Detect chemical contamination in all its physical forms
- Range resolve, quantify and map data
- Survive in an NBC environment

The purposes of the program are to:

- Demonstrate concept feasibility
- Establish capabilities and limits
- Complete science base
- Determine effectiveness in combat situations
- Establish basis for rapid transition to mature development

The IR DISC/DIAL system can develop data in four ways (as shown in Figure 1):

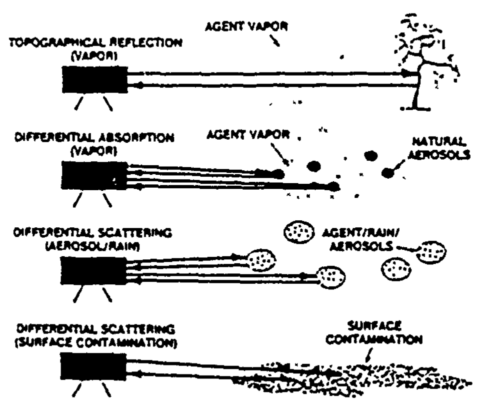

Fig. 1

TOPOGRAPHIC REFLECTION DIAL

By transmitting different IR frequencies and detecting their topographic return, chemical vapor clouds can be identified by their selective absorption of some of the IR frequencies. This measurement detects the presence of the cloud and its total concentration times path length (CL); however, it does not tell you how far away the cloud is or its density (concentration).

AEROSOL BACKSCATTER DIAL

By the same technique, but with higher laser powers, the normally occurring atmospheric aerosol begins to reflect IR energy back to the detector. This distributed reflector can be "range resolved" by gate timing the returning signal just as radar systems do. In this way, average concentrations and ranges can be developed for many cells (range lines) down the LIDAR path. By scanning the system spatially, a map can then be made of vapor chemical agents.

AGENT BACKSCATTER DISC

In the same manner, chemical agent aerosols and agent rains can be detected by the selective frequencies that they directly backscatter to the detector.

SURFACE REFLECTION

The fourth mode of detection is the detection of selective IR frequencies backscattered from agents on surfaces. This measurement is dependent on the amount of material located on the surface of dirt, grass, trees or equipment.

Figure 2 shows that, for each of the detection modes, the return signals are different so that all measurements can be made simultaneously. This is important because there are no significant hardware design constraints to add aerosol rain and surface detection to an aerosol backscatter DIAL system.

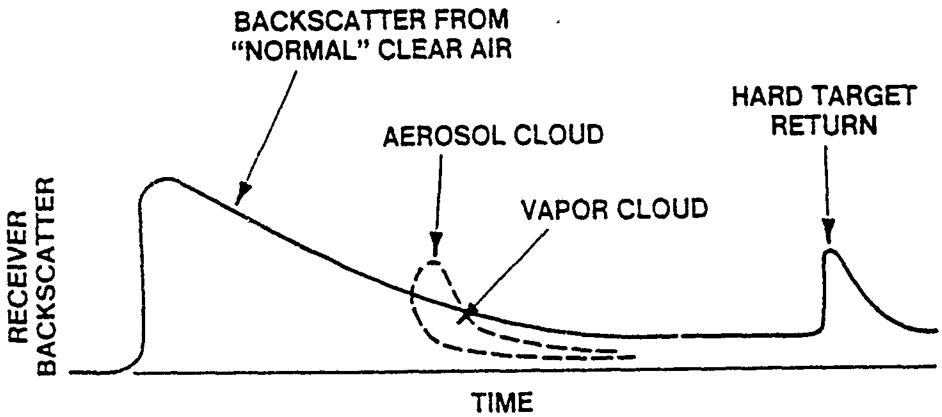

Fig. 2

The DISC/DIAL project was initiated in 1982. The first objective was to build a Ground Mobile Breadboard (GMB) system to demonstrate the feasibility of DISC/DIAL chemical detection. This system was mounted in a van and successfully tested in FY84 and 85. Based on each of these tests, the GMB was upgraded. The current specifications of the Ground Mobile Breadboard Upgrade (GMBU) are:

<u>Transmitter</u>

Lasers	Four CO_2 TEA Laser
Tunability	Line-Tunable by Grating
Wavelengths	9.2 to 10.8 Microns
Energy (on 10P20)	2.0 J/Pulse
Pulse-to-Pulse Power Stability	$\pm$ 3 Percent
Pulsewidth (3dB)	90 ns
Repetition Rate	20 Hz
Beam Divergence	3.5x4.0 MRAD
Mode	Multimode or TEMoo
Timing Jitter	2 NS Pulse-to-Pulse

<u>Receiver</u>

Telescope Diameter	16 Inches
Detector	HgCdTe Quadrant
Size	1x1 mm Per Element
Detectivity	$4x10^{10}$ $cm/Hz^{1/2}$ w
Field of View	8 MRAD
Overall Electronic Bandwidth	10 Hz to 7 MHz

The upgraded GMBU along with 12 other devices were then exposed to extensive U.S. Army Dugway Proving Ground (DPG) field testing in the fall of 1986. The goals of these tests were:

(1) Investigate effects of reducing agent system size, weight and power on detection performances. This was because the Army's near term use was a ground mobile vehicle application for reconnaissance.

(2) Obtain quantifiable data on vapors, aerosols, and liquid detection and on interferences to prove feasibility.

(3) Use more realistic battlefield scenarios to develop workable use concepts.

These tests involved large scale simulant clouds created by a special 100 meter long spray system, aircraft spray, and artillery deployment. Also, aerosols were generated by spray from a high ranger boom, and surfaces (such as dirt, grass, concrete, trees, or vehicles) were coated with simulants. The many accomplishments of these large scale tests are:

- Demonstrated feasibility of DISC/DIAL technology
- Demonstrated high feasibility
- Demonstrated operation in motion, scanning and mapping
- Detected cloud through a cloud

- Detected collocated DMMP and SF_6
- Detected DMMP
    - up to 5 Km (range resolved)
    - up to 10 Km (column-content)
    - in presence of all interferents (fog, rain, dust and military smokes)
    - on ground by secondary vapor
    - at night and in reduced visibility
    - in calibrated chamber
- Detected SF96 - as an aerosol
    - as ground contamination on six surfaces
- Detected other volatile and non volatile simulants
- Validate emulation and simulation models

Additionally, this field work was backed up with an extensive emulation and simulation program which was able to show excellent correlation between predicted and actual performance.

Figure 3 shows a typical GMBU map of a simulant vapor cloud. Note the range cells are colored to show the average concentration from 0.1 to 2.0 mg/m^3.

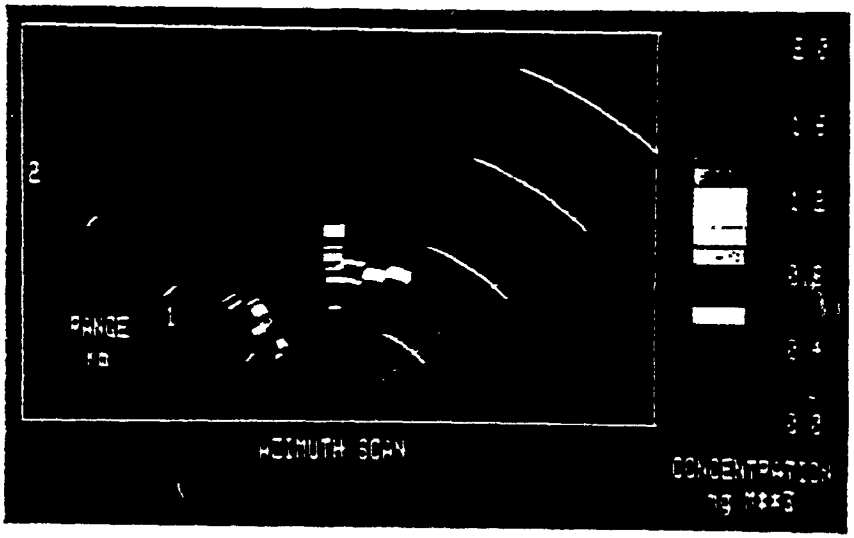

Fig. 3

The UV LIF based laser radar was also successfully tested for biological and toxin materials. While not nearly as far along in development as the IR system, this system demonstrated significant detections at ranges up to 1.2 Km. The system, which measures the laser induced fluorescence of Tryptophane, a compound occurring in all living material, can sense the presence of biological/toxin clouds but cannot as yet uniquely identify the material. Relative optical discrimination between biological simulants and interferents/backgrounds of UV/LIF are shown below:

	Scattering Signal Level 248 nm	Fluorescence Signal Level 280-410 nm
Tryptophane	None	Strong
BG	None	Strong
Egg Albumen	None	Strong
Diesel Exhaust	Small	Strong
Auto Exhaust	Small	Weak
Road Dust	Strong	None
Trees	Strong	Strong

Other optical concepts based on Mueller Matrix scattering are currently being investigated to add additional identification capabilities to UV/LIF system.

Because more time will be required to evolve the UV LIF system, it is being planned as a P^3I to add on to the IR DISC/DIAL chemical detection system as the technology is fully demonstrated.

It has taken the efforts of many people in numerous organizations to accomplish the Stand-Off detection program in so rapid a manner with such success. The agencies which have been and are currently contributing to CRDEC's Stand-Off detection effort are:

Contractors	OGA/Joint Services	Universities
GTE	ASL	MIT Lincoln Labs
Honeywell	Brooks AFB	University of Arizona
Hughes	DPG	University of Iowa
Lockheed	EPA	University of Maryland
MIDAC	LANL	University of Oklahoma
Raytheon	Marine Corp Development Center	
SRI International	NASA-Langley Rsch Center	
STC	NSWC	
TI	CNVEO	
	USAF-Avionics Lab	
	USAF-Geophysics Lab	
	JPL	
	Waterways Experimental Station	

As we stated before, the Army is primarily interested in a ground mobile vehicle application for this technology. Current Army efforts are being directed to reduce the size and weight of the system while maintaining full detection capability at a 2-3 Km range. Future Army work will focus on detection from helicopters, RPVs, other air mobile platforms, and eventually even from space borne platforms.

Meanwhile, the larger GMBU is being upgraded to a full prototype status for two separate applications which do not require small size and low weight. The first is a project for DPG to provide real time, high resolution concentration mapping of clouds for "ground truth" on their test range. The second application, for air based defense, is sponsored by Brooks Air Force base.

This project, called Airbase Long/Short Range Chemical Detector (ALSRCD), will be the first military application of laser Stand-Off detection for chemical defense.

In summary, CRDEC has demonstrated the feasibility of IR DISC/DIAL technology for the detection of chemical agents in all forms. We are beginning to develop prototypes for ground mobile, fixed site and test facility application. The potential exists for modifying these systems to mount on helicopters, RPVs, and even satellites, and to add the capability of detecting biological and toxin agents.

AREA AND REMOTE DETECTION IN AN AIRFORCE BASE ENVIRONMENT

by Maj. Gen.(Ret.) Pierre RICAUD

French Defense Science Board

Chemical attacks on an airforce base can be detected by local automatic detectors as those the different NATO Air Forces are equipped with. But the survey of the whole surface of a base, in view of knowing its operability and the hazard evolution, demands either a network of sensors, with a centralized treatment of their data, or a central remote detection system scanning the landscape.

CHEMICAL DETECTORS NETWORK

Gathering information of several local detectors lets determine the location and size of a chemical cloud. The comparison of answers allows to eliminate individual variations from apparatus deficiencies or ground unevenness.

The Air Base nuclear and chemical survey system developped by the Centre d'Etudes du Bouchet includes

- a central unit
- local chemical warning detectors DETALAC
- nuclear probes

the connection between the central unit and the sensors being made through the base telephonic network up to 3 miles. 16 sensors can be connected.

- the DETALAC (Fig.1) is a flame photometer adjusted on the wavelength of the maximum light emitted by the POH radicals, during the combustion of organophosphorous compounds in a reducing hydrogen flame. Its sensitivity is high, up to 0.1 mg/m^3, with a short response time : 2 seconds for an organophosphorous concentration higher than 2 mg/m^3 , 2 minutes if it is higher than 0.1 mg/m^3. It is provided to the French forces (1) in different types according to the Services users.
- An interface connects the DETALAC to the Central unit from which it sends orders to the detector:on/off, alarm cancellation, test of the apparatus

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(1) by GIAT

functions. Reversely it sends to the central unit, through a Modem, after preprocessing, DETALAC informations.

- The central unit (visual control consol - VCC) (Fig.2) provides full operator-sensor dialogue capabilities, through its Modem and microprocessor: it identifies and questions the different sensors, performs calculations for N and C forecasts... It displays on its color monitor pictures describing f.e. the general status of the network (Fig.3), barcharts of the measured parameters, in real time, with automatic recall of alarms and faults (Fig.4), nuclear or chemical stations status (Fig.5), system function and operating mode menu (Fig.6). Using the three keyboards on the VCC, the operator selects system functions, enters digital data for calculation, selects the figures and controls the monitor.

The system can also perform simulations for demonstration and training purposes.

It is in the production phase for equipment of the main FAF bases, and some are already equipped.

...

REMOTE ALARM DETECTION

Instead of a network of local detectors, a central scanner could look for toxic agents in several directions. This will be achieved with DETADIS (Fig.7), a system (2) based on the differential absorption by organophosphorous toxics clouds of CO_2 infra-red laser beams between 9 and 10 µm (Fig.8). This absorption is due to P-(O)C vibrations, and is located in a good atmospheric window. The signals emitted by a TEA impulsional CO_2 laser are backscattered on obstacles behind the monitored area (Fig.9 & 10). These obstacles may be artificial (trihedron mosaics f.e.) or natural (walls, trees...).

THE APPARATUS (Fig.11)

It is made up of

- an emission /reception unit
- a process unit
- a tripod

The head is composed of two CO_2 lasers, a reference one ($\lambda = 9,26\ \mu m$) and a measurement one with a grating varying the emitted wavelengths: the two beams are

(2) developped by CILAS under Centre d'Etudes du Bouchet contract

perpendicularly polarized, then mixed. A part of the mixed beam is sampled toward a pyro-electric detector, for measuring the emitted power (Fig.12). The beam, emitted and backscattered, crosses afocal dioptric systems and is received on a photoelectric detector - a Hg Cd Te cell cooled by Nitrogen expansion.

A telescope, with a final optical axis parallel to the laser one, lets the operator select at first the reflecting targets with a mirror set inside an upper rotating cap (for azimuthal search)(Fig.13). The mirror itself moves for elevation search within ± 10°. The two movements are motorized and the orientations toward the selected targets memorized. This mirror reflects the three beams (emission, return and sighting).

The process unit includes

- an amplification, conversion and synchronisation unit, with an anti-blindness system avoiding backscattering on too near obstacles by elimination of too early echoes (the distance being adjustable)
- a system controlling the power emitted for each wavelength
- a compensator of the target albedo to keep between two limits the backscattered signal from the target, without toxic cloud
- a control board for system starting and aiming, and for initiation of measures
- a computer for storing external and internal data, and treating the measured values.
- a display giving indications on the state of the system, and the results of measures, with, casually, indications on the nature and the concentration of toxics.

The tripod bears, in addition to the emission/reception and the process units, two cylinders of gases : the mixture (N_2, CO_2, He) for lasers and liquid Nitrogen for receiver cooling.

OPERATIONS

After placing the system in its initial conditions, the operator searches for the reflecting targets through the telescope, and validates them according to their albedo by 10 pulses of the reference laser (10 Hz frequency), the computer adjusting the receiver-attenuator for each target and memorizing their position. The operator may then initiate a "watch sequence": the system scans each memorized target, according to increasing azimuths by emission of 10 pulses (10 Herz) of the laser: reference and measure for the line P44.

If the line P44 is absorbed, which is measured by a ratio

$$\frac{E_M}{D_M} \Big/ \frac{E_R}{D_R} \quad \text{different from 1}$$

E_M = amplitude of the measure laser echo

D_M = amplitude of the measure laser emission

E_R = amplitude of the reference laser echo

D_R = amplitude of the reference laser emission

The computer controls the emission of 7 other lines, establishes the absorption spectrum and compares it to the memorized spectra. It displays then the nature of the toxic, and its concentration in the direction of that target.

This concentration is given in mg/m^2.

The system measures indeed the product concentration (mg/m^3) x toxic cloud thickness (m).

The operator may then reinitiate the sequence, for scanning the other targets. After the last target, the system turns back to the first one, step by step, with emission toward each of them of the line P20.

PERFORMANCES CHARACTERISTICS

Range = 5 km with natural targets (6 km with artificial ones)

Sensitivity = 500 mg/m^2

Response time : less than 60 secondsfor a whole scanning

Number of memorized targets = up to 10

Scanning angle = 90°

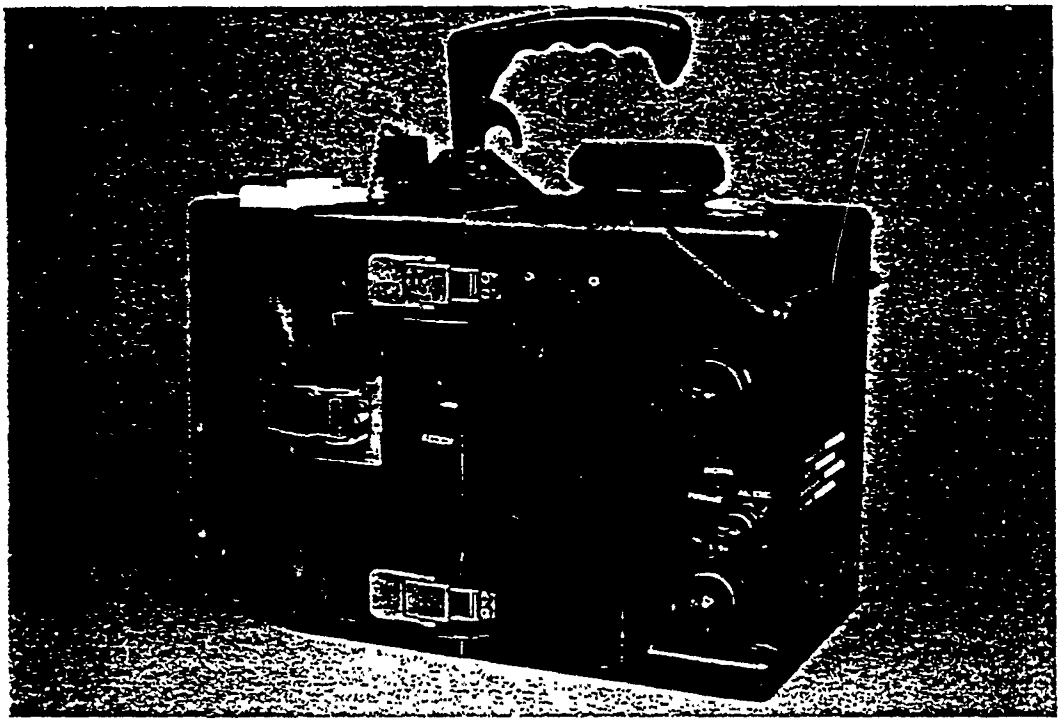
Autonomy = 4 hours with two 5 liters gas cylinders pressurized at 200 bars.

Placed on a control tower of an airbase, this system will allow the automatic survey of a large sector of the base, giving alarm warning in case of a nerve agents attack, with indication of the nature and the concentration of the toxic, delimitation of the toxic cloud width and forecasting of its evolution.

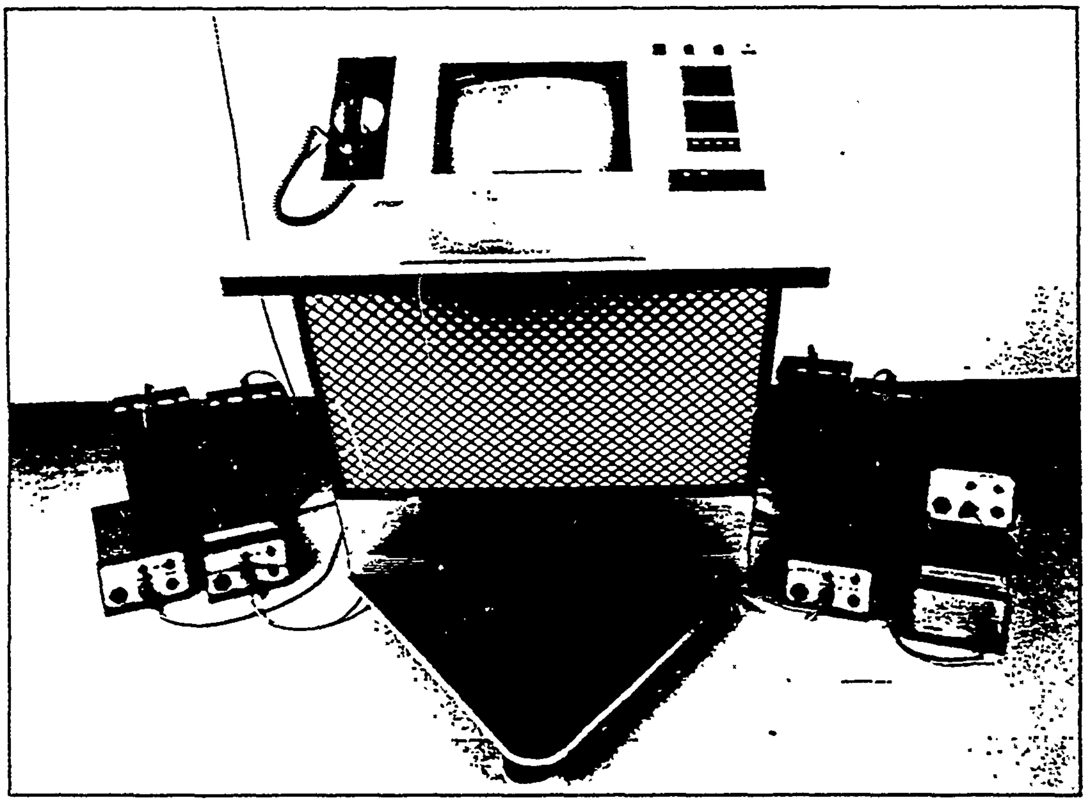
But the need of natural reflecting targets will not allow the detection and identification of clouds in the sky, from air spray tanks or bombs or missiles bursting in altitude.

This possibility might be given by MIE-Backscattering on atmospheric particles, normal or toxic ones. This process would give also informations about the depth and distance of the toxic cloud. But a lot of basic researches are needed to establish even the feasibility of such a system.

DETALAC Mle F1



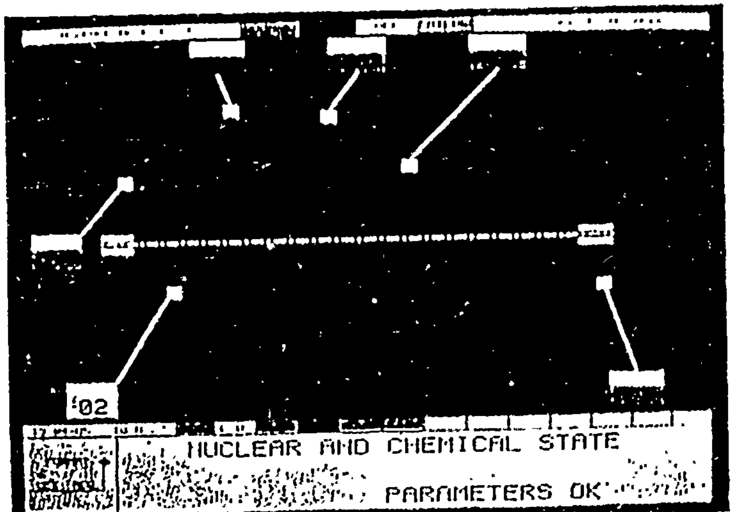
NUCLEAR AND CHEMICAL (NC) MONITORING SYSTEM FOR AIR FORCE BASES



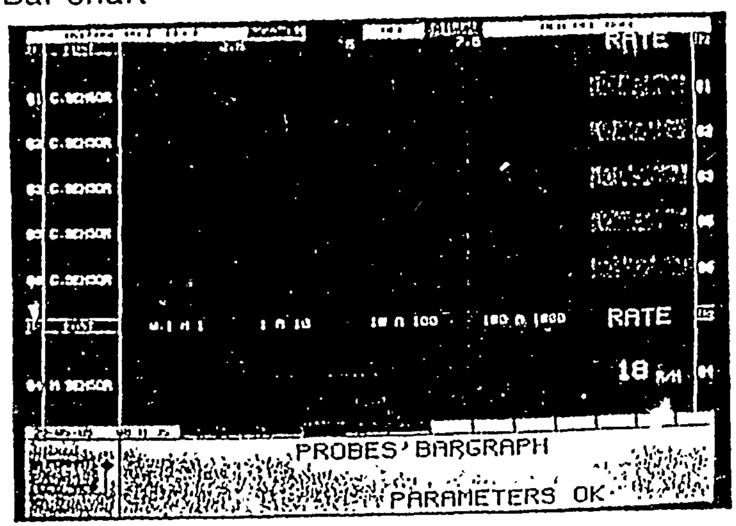
VDU/Control Console (VCC)

Fig 2

MAIN PICTURES
THAT CAN BE CALLED UP ON SCREEN



igure 3 : General status of the network



igure 4 : "Bar chart"

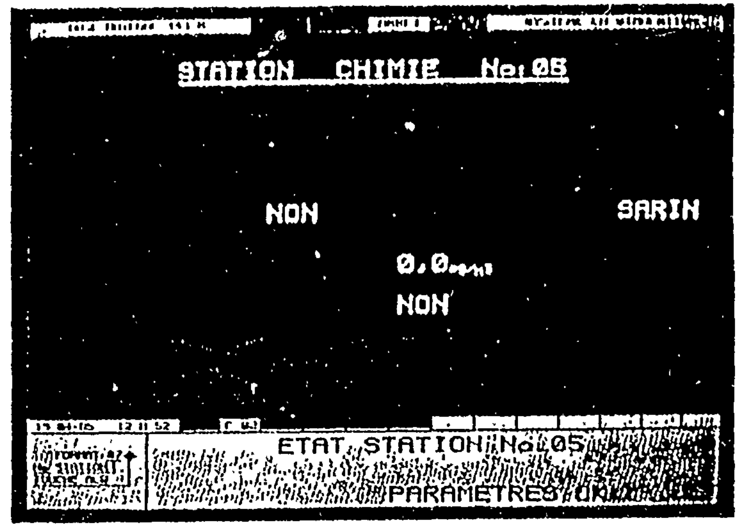


Figure 5 : Nuclear or chemical stations status

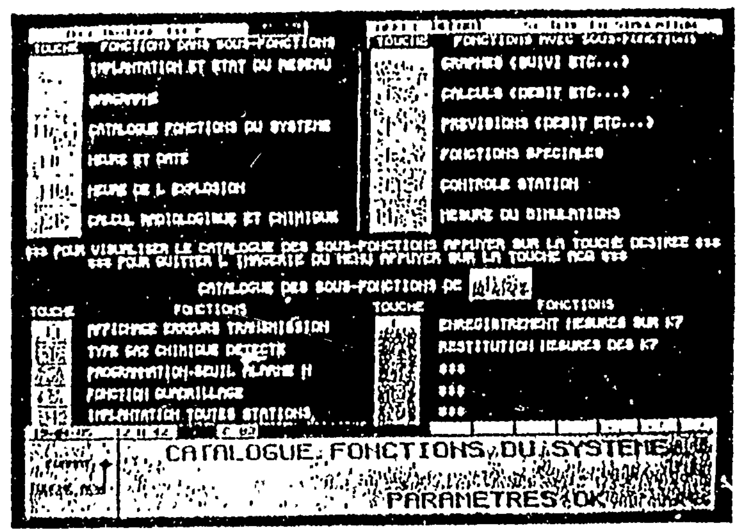
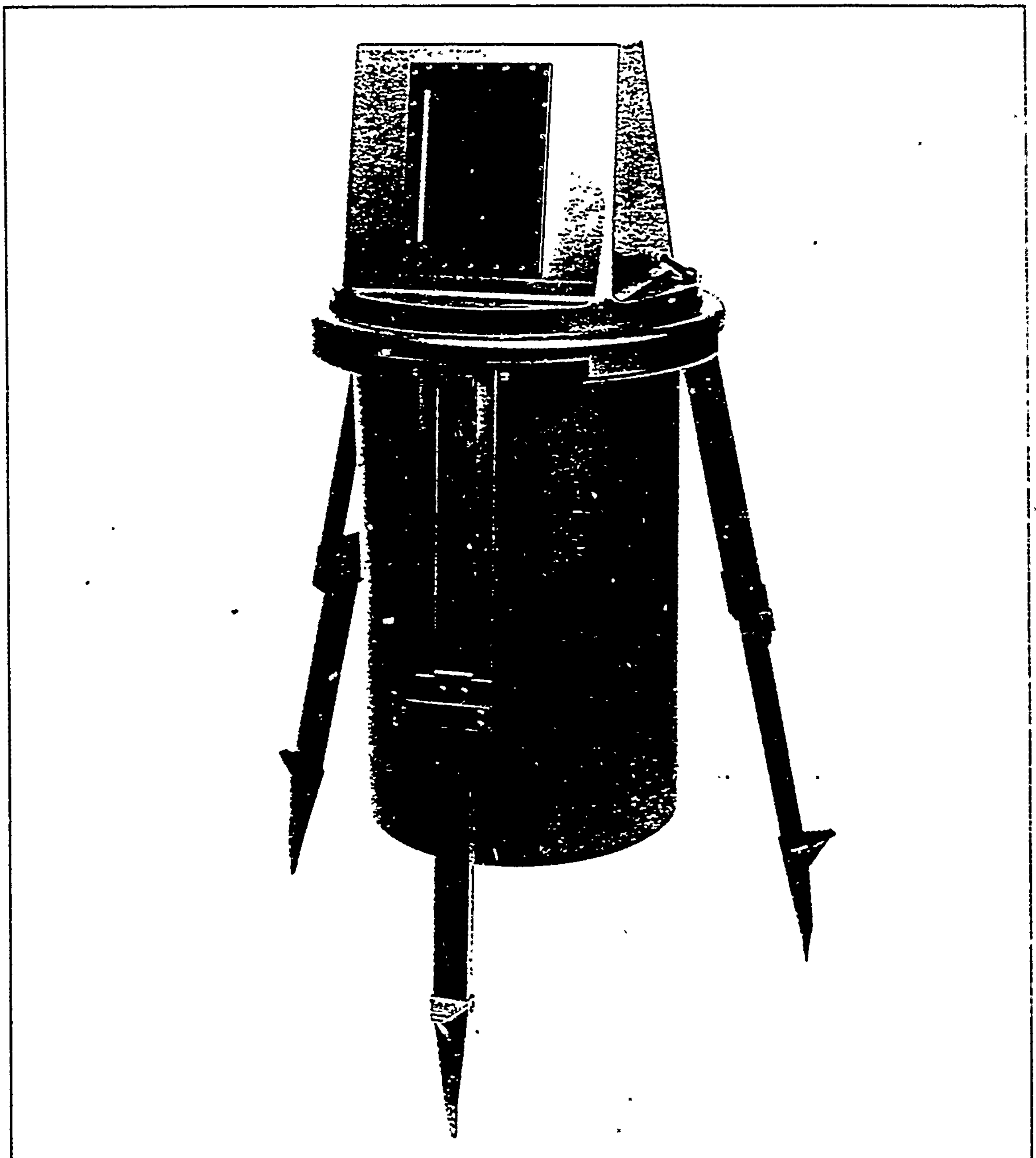


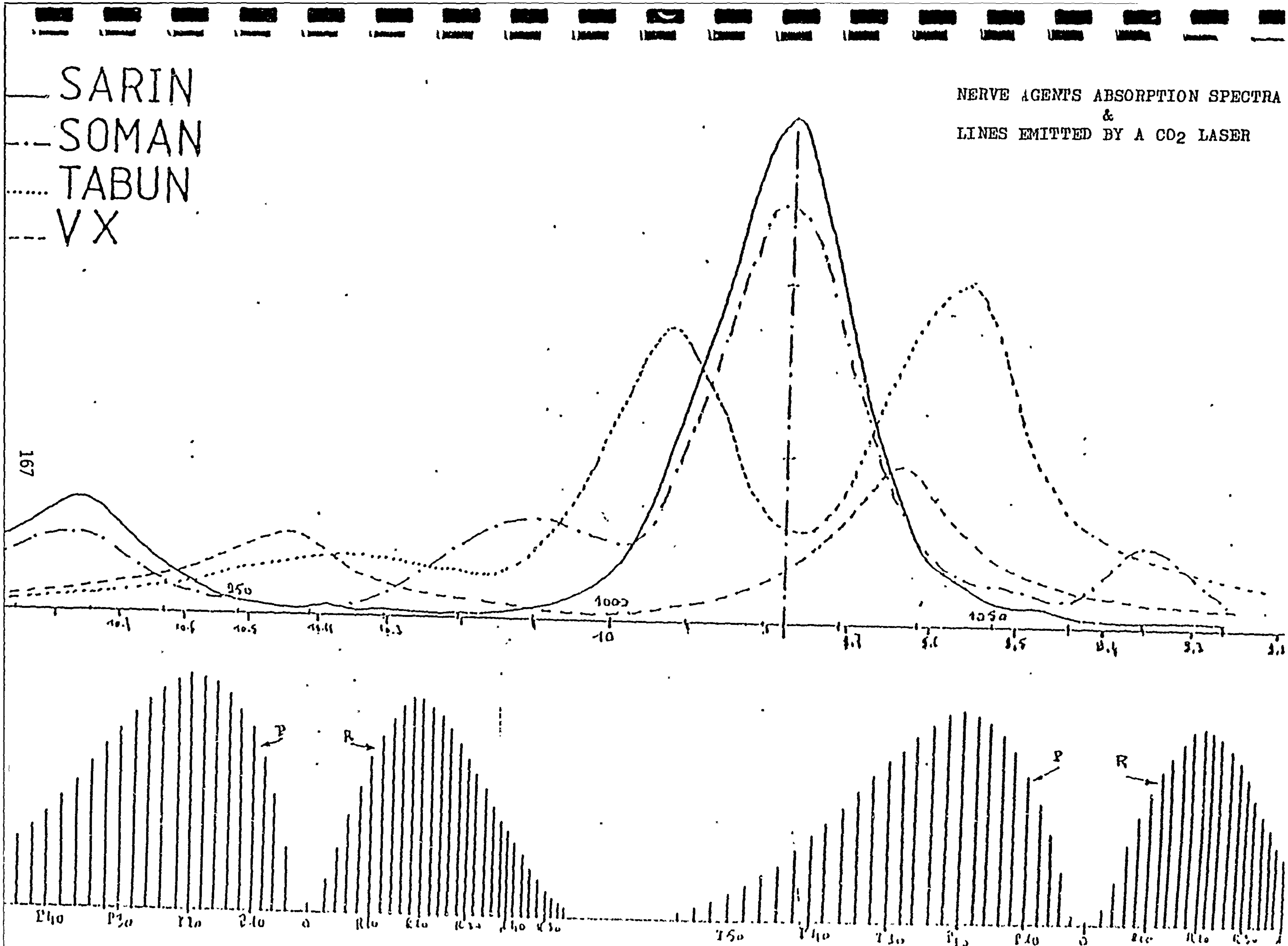
Figure 6 : Catalogue des fonctions . Op. Mode Menu

DETADIS
Chemical agent remote alert detector



CILAS

C.G.E


SARIN
SOMAN
TABUN
VX
NERVE AGENTS ABSORPTION SPECTRA
&
LINES EMITTED BY A CO_2 LASER
P
R
P
R
10

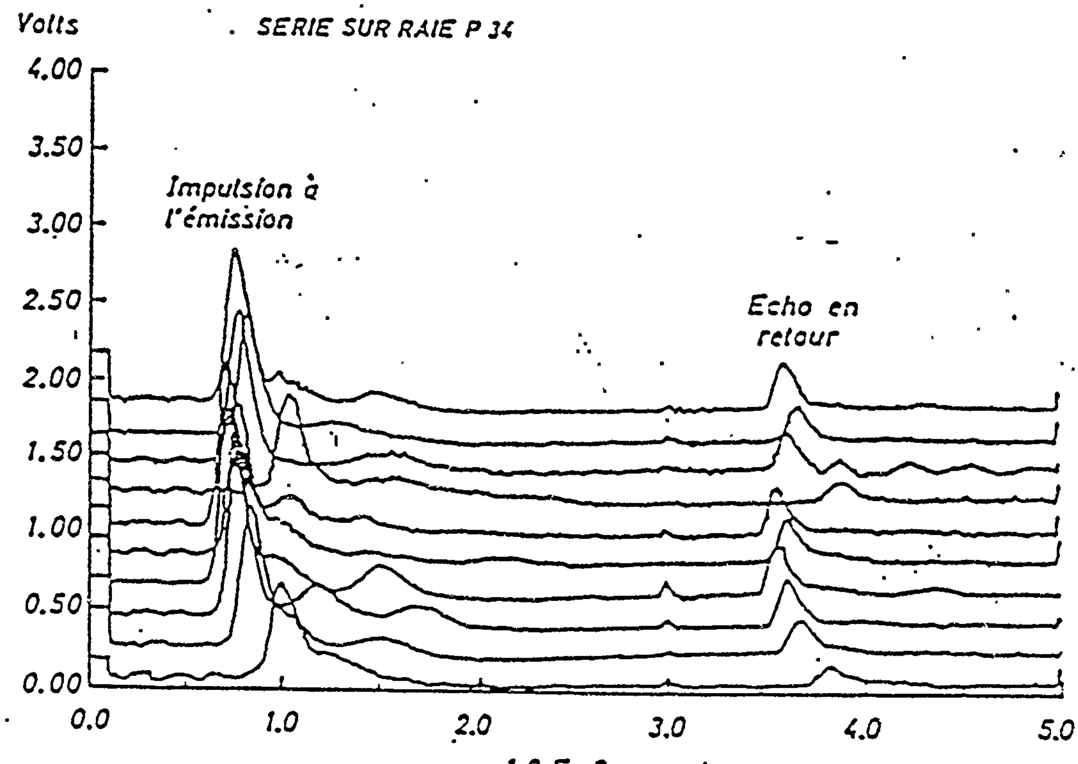
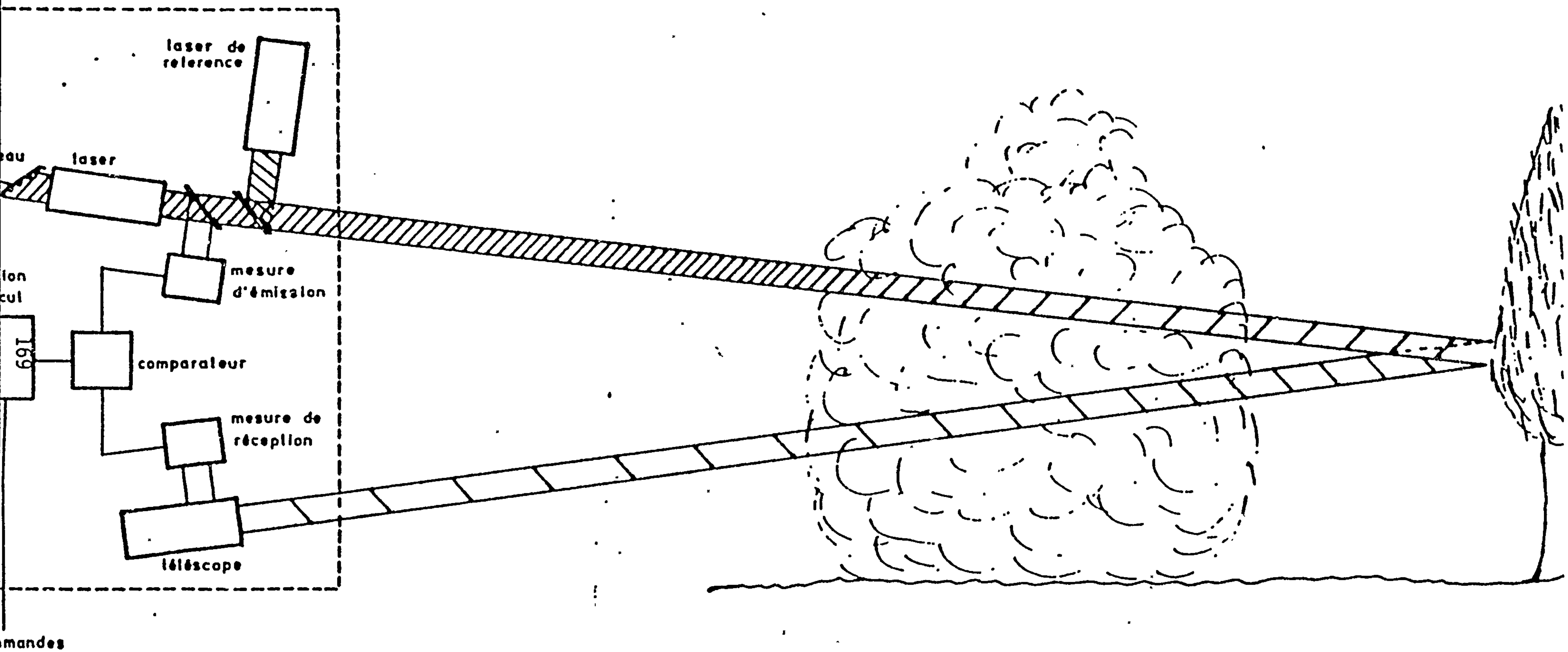


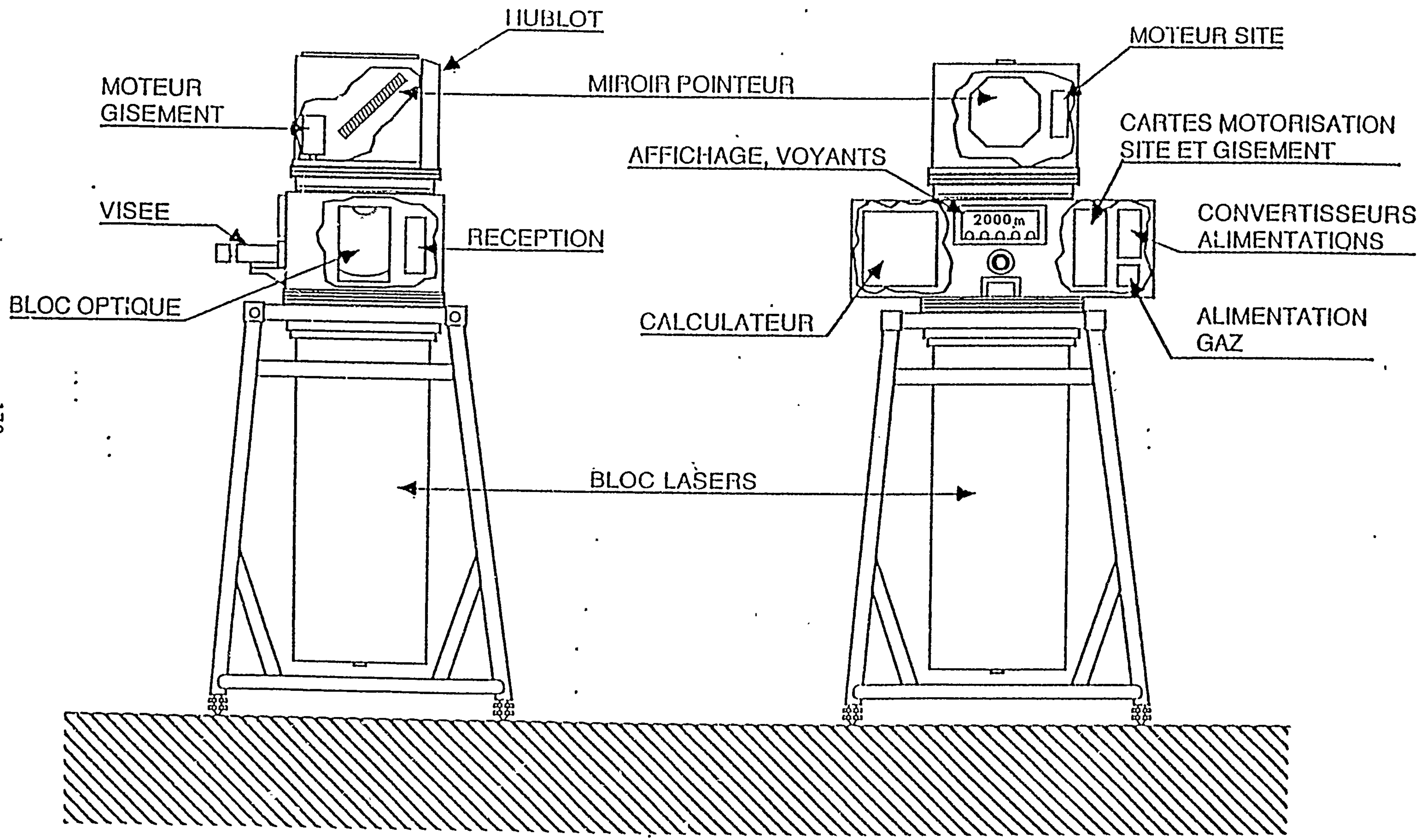
FIG 9

LASER BEAM BACKSCATTERED ECHOES



DETADIS

SCHEMA DE PRINCIPE


HUBLOT
MOTEUR GISEMENT
MIROIR POINTEUR
MOTEUR SITE
CARTES MOTORISATION SITE ET GISEMENT
AFFICHAGE, VOYANTS
VISEE
RECEPTION
2000m
CONVERTISSEURS ALIMENTATIONS
BLOC OPTIQUE
CALCULATEUR
ALIMENTATION GAZ
BLOC LASERS

DETADIS

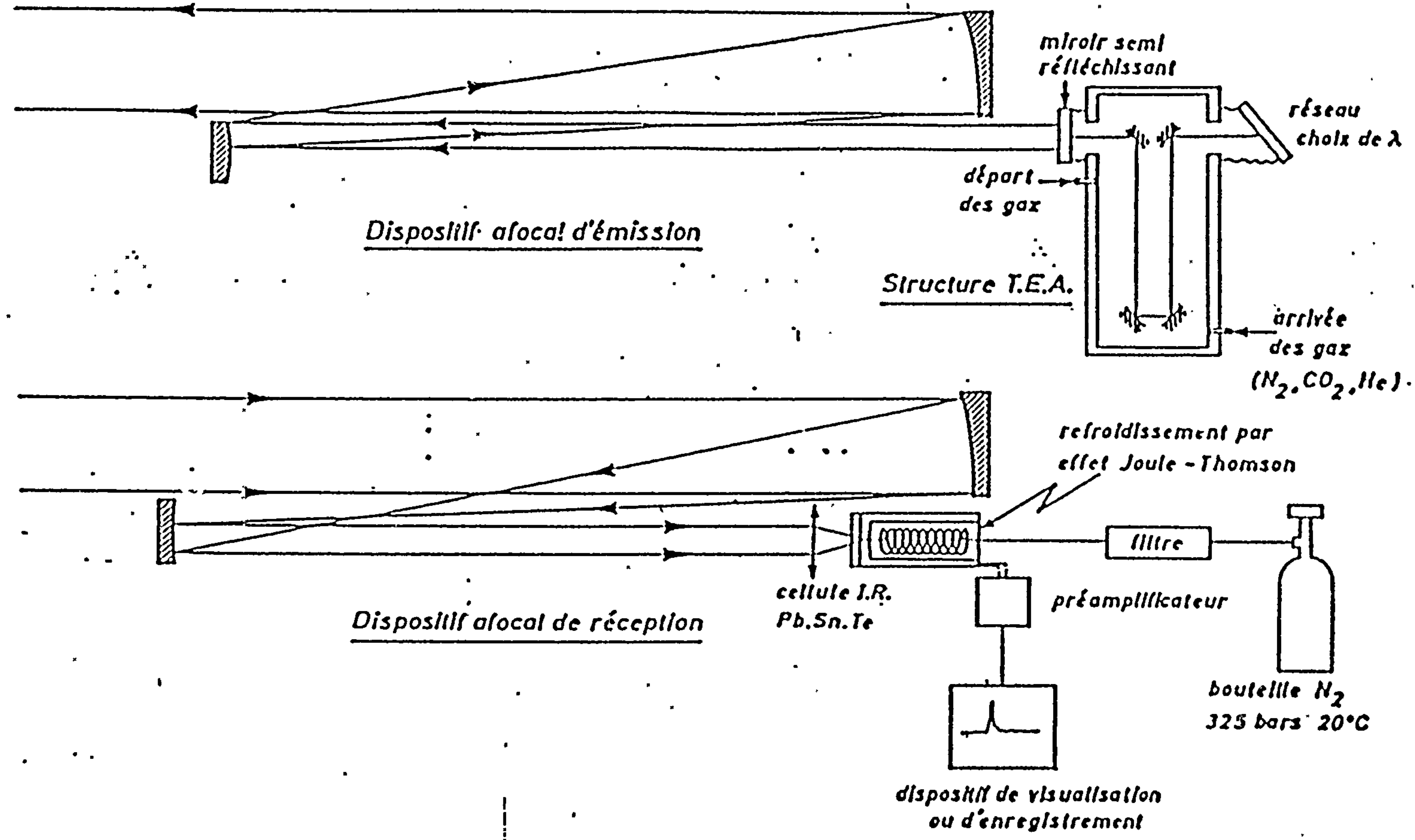
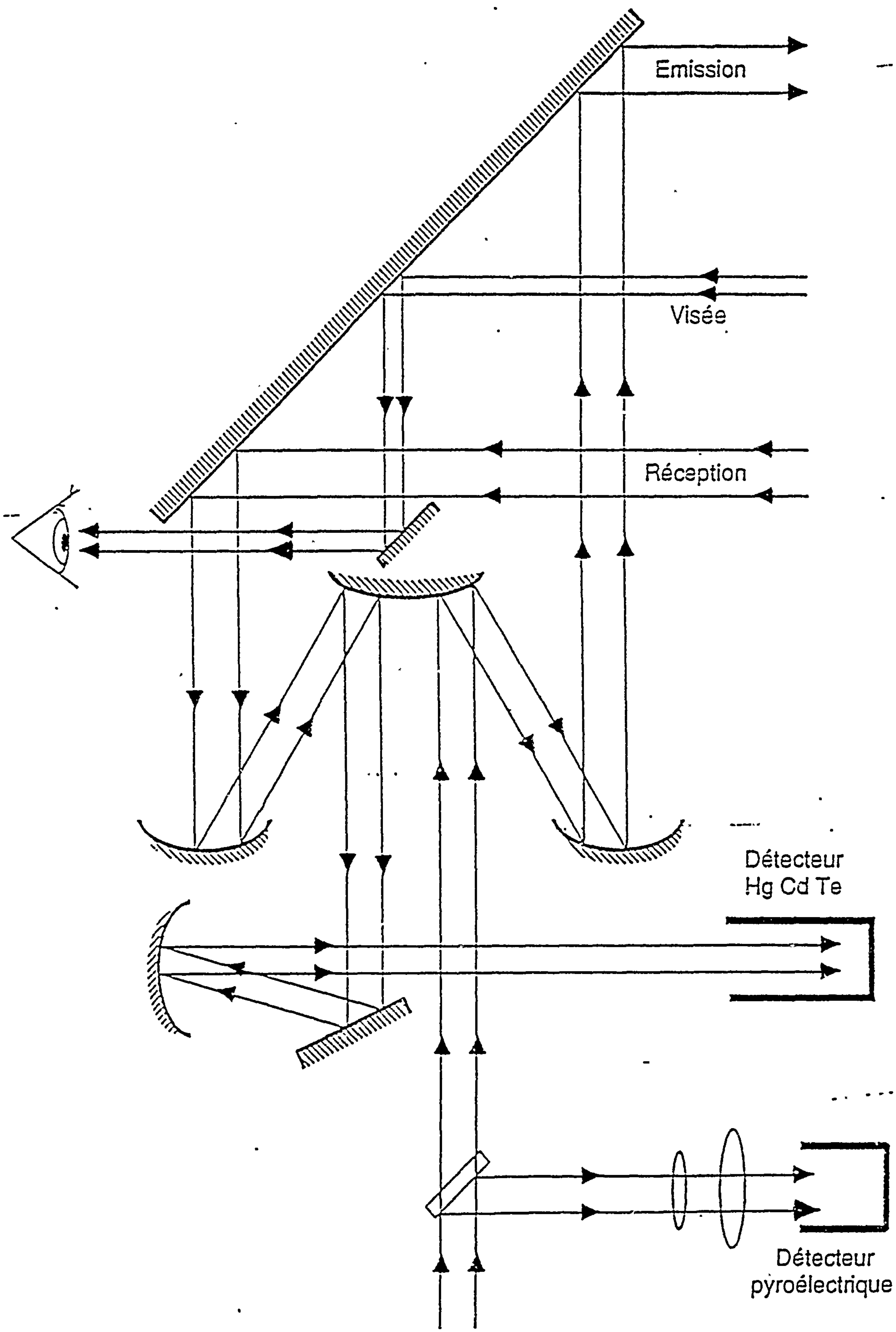
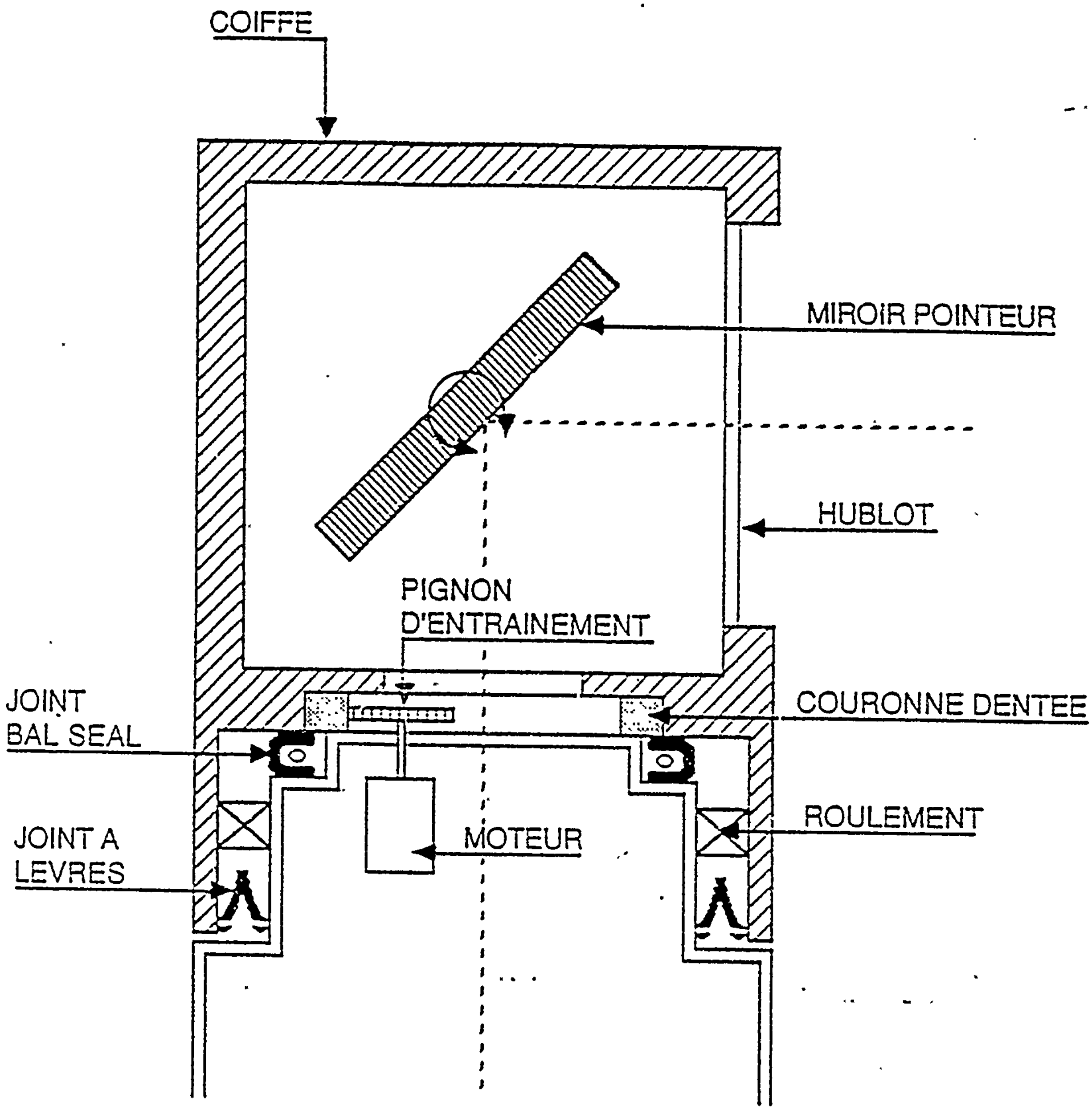


FIG 10
Schéma du Détadis



DISPOSITIF OPTIQUE



COIFFE

Fig 13.

FIXED SITE AND WARNING DETECTION (FSDWS)

Lt. Jeffrey C. Stephan

This paper is intended to provide the reader a brief overview of the Fixed Site Detection and Warning System (FSDWS) and related work.

Some of the first work done in the area of detector integration was done during 1982-3 under an ASD/AESD contract awarded to VERAC. This work was advanced under several contracts by the Army through the Chemical Research Development and Engineering Center (CRDEC) and the Air Force through the Human Sciences Division (HSD). Currently, the Armstrong Aeronautical Medical Laboratory (AAMRL) special projects office has on-going work in the area of chemical hazard analysis and air base modeling. Mr Foley, LtCol Dixon, and Dr Replogle have all submitted papers concerning modeling aspects of chemical detection, identification and warning.

The 1983 Integrated Chemical Detection and Warning (ICDW) Study showed that an integrated system has great potential for reducing the number of casualties received as a result of a chemical attack. The study concluded that the greatest benefit would be received by using a mix of point and remote detectors and that an automatic liquid agent detector would be a critical part of such a network. Such a network would enhance the utility of point sensors through reduced missed detection rates, reduced false alarm rate, and a higher detection rate.

The purpose of the integrated system is to provide an early indication that a chemical attack has occurred and notify the commander. The commander can instruct base personnel to take the appropriate protective actions. After a chemical warfare attack, the system will assist in determining agent identification, concentration, locations, etc. The system will be critical tool in determining an all clear condition.

A secondary purpose of the system could be to provide a data base for resource management. The system could also be merged with elements of the Chemical Hazard Assessment System (CHAS), discussed further in the above mentioned modeling papers, to provide scenarios for training purposes and aid in carrying out those scenarios.

How will the system work? Detectors of varying types will be distributed over the base. Alarm signals and data from alarming detectors will be transmitted over a communications system to a central command post. The incoming data will be processed by a computer via a chemical hazard assessment model and resulting information will be diplayed in a useful form. The communications system to transmit data from the detectors to the command post computer has not been choosen yet, but could be the Survivable Base Recovery After Attack (BRAAT) Communications System (SBCS) managed by ESD/XRB.

The computer is needed to automate the monitoring of the detectors and provide the operator with an alarm indication.

After an alarm the computer is required in order to make hazard predictions and convert resulting information into useable graphical form. The computer will also be used to input data from automatic detectors not on the network and non-automatic detectors such as detector papers, detection kits, casualties, etc.

The plan for the program is to define an objective system meeting total base detection and warning requirements. TRW is currently under contract to do this through an Army task order contract. Concurrently, a Statement of Operation Requirements Document (SORD) is being drafted by U.S. Air Forces in Europe (USAFE). Once an objective system has been defined ASD will look at short term solutions that can provide some or all of the capability of the objective system requirements. A plan will be developed to guide development from this initial partial capability system to a full system meeting the objective system requirements. TRW is currently drafting such a plan under the aforementioned contract. In choosing an initial system we will compare factors such as cost, maintenance burden, percent of requirements satisfied, schedule requirements and funding available.

Part of FSDWS requirements will be that the system be expandable. As future detectors become available they should easily be added to the system with minimal software changes to FSDWS, possibly by just adding its characteristics to a database. In addition to adding more reliable and advanced detectors to the system, one could foresee the addition of biological detectors and possibly radiation detectors to the system.

ASD/AESD's current plan is to award a systems contract, through full and open competition, to a contractor that would be responsible for meeting requirements of both an initial and the objective system. This contractor would be responsible for obtaining or developing detectors necessary to fill any gaps in detectors currently or expected to be fielded by the Air Force. The objective of the contract would be to fulfill total base chemical detection and warning requirements for a fixed site.

To summarize, the Air Force is currently analyzing basewide detection and warning requirements and are baselining a system that meets total requirements, while determining what capabilities can be fielded near term. AESD is developing a coherent plan for system development. New detectors will probably be required for a system meeting total base wide chemical detection and warning requirements. A systems contractor will be responsible for both developing and producing initial and objective systems.

FIXED SITE DETECTION AND WARNING SYSTEM

NATO
INTERNATIONAL CONFERENCE

"FIXED SITE DETECTION AND WARNING SYSTEM"

31 AUG - 4 SEP

WILLIAMSBURG, VIRGINIA

PROGRAM MANAGER: LT JEFF STEPHAN

FIXED SITE DETECTION AND WARNING SYSTEM

PAST WORK

- INTEGRATED CHEMICAL DETECTION AND WARNING STUDY, 1983
- CRDEC/HSD SPONSORED STUDIES, 1985-6
- AAMRL SPONSORED MODELING, 1986-7

FIXED SITE DETECTION AND WARNING SYSTEM

OVERVIEW

- BACKGROUND
- PURPOSE
- DESCRIPTION
- PLANS
- SUMMARY

FIXED SITE DETECTION AND WARNING SYSTEM

FINDINGS

- A REAL OR NEAR REAL TIME DETECTION AND WARNING SYSTEM HAS POTENTIAL TO REDUCE CASUALTIES
- UTILITY OF POINT SENSORS GREATLY ENHANCED THROUGH INTEGRATED APPROACH
  - REDUCED MISSED DETECTION RATES
  - REDUCED FALSE ALARM RATE
  - HIGHER DETECTION RATE
- AN AUTOMATIC LIQUID AGENT DETECTOR IS AN ESSENTIAL ELEMENT OF AN INTEGRATED SYSTEM
- IDEAL INTEGRATED SYSTEM REQUIRES A MIX OF POINT AND REMOTE DETECTORS

FIXED SITE DETECTION AND WARNING SYSTEM

PURPOSE

- PRE-ATTACK & TRANS-ATTACK
  - MONITORS DETECTORS
  - PROVIDE WARNING
- POST-A[illegible]K
  - PROVIDE BASE CONDITIONS
  - PROVIDE AGENT IDENTIFICATION, CONCENTRATIONS, ETC
  - PERFORM HAZARD PREDICTIONS
  - PROVIDE ALL CLEAR INDICATION

FIXED SITE DETECTION AND WARNING SYSTEM

DESCRIPTION

- DETECTORS (MIXED TYPES) DISTRIBUTED OVER BASE
- ALARMS AND DATA TRANSMITTED VIA COMMUNICATIONS SYSTEM
- DATA PROCESSED BY COMPUTER
- RESULTS DISPLAYED IN USEFUL FORM

FIXED SITE DETECTION AND WARNING SYSTEM

SECONDARY FUNCTION (SUPPORT)

- PROVIDE TOOL FOR RESOURCE MANAGEMENT
  - PERSONNEL, BLDG STATUS, ETC.
- TRAINING
  - WHAT IF'S
  - EXERCISE SCENARIOS

FIXED SITE DETECTION AND WARNING SYSTEM

DESCRIPTION

COMPUTER:

- MONITOR DETECTORS
- PROVIDE ALARM INDICATION
- PERFORM HAZARD PREDICTIONS
- GENERATE DISPLAY
- ALLOW MANUAL INPUT OF DATA
- PROVIDE TRAINING SCENARIOS

PLANS

- LONG TERM
  - SYSTEM REQUIREMENTS DRIVEN (TOP DOWN)
  - OBTAIN OBJECTIVE SYSTEM SYSTEM SPECIFICATION
- SHORT TERM
  - OBTAIN MARKET ANALYSIS
  - RESEARCH CURRENT OPTIONS
  - PROVIDE OPTIONS MATRIX
  - OBJECTIVE: IMPROVED OPERATIONAL CAPABILITY

STRATEGY

- FULL AND OPEN COMPETITION
- AWARD SYSTEMS CONTRACT
- SYSTEMS CONTRACTOR RESPONSIBLE FOR:
  - BOTH SHORT AND LONG TERM SYSTEMS
  - DETECTORS TO FILL GAPS
    - -- CAN USE U.S. OR FOREIGN SOURCES

FIXED SITE DETECTION AND WARNING SYSTEM

PLANS

- STRUCTURED DEVELOPMENT LINKING SHORT TERM TO LONG TERM SYSTEMS
- PROVIDE MODULAR SYSTEM
  - EXPANDABLE
    - -- BIOLOGICAL
  - UPGRADEABLE

FIXED SITE DETECTION AND WARNING SYSTEM

SUMMARY

- US CURRENTLY ANALYZING REQUIREMENTS FOR BASEWIDE DETECTION AND WARNING SYSTEM.
- BASELINING SYSTEM TO MEET THOSE REQUIREMENTS.
- NEW DETECTORS ARE REQUIRED FOR SYSTEM
- SYSTEM DEVELOPMENT FOLLOWING A COHERENT PLAN

CHEMICAL HAZARD ASSESSMENT SYSTEM
(CHAS)

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The results of the command post exercise (CPX) known as Salty Chase 87 were threefold. We were able to provide a realistic portrayal of a combined conventional and chemical attack on an airbase. Predictably, we saw the need for increased training in chemical defense. However, the unexpected result was the extreme usefulness of this particular CPX as a training tool for the battle staff. This was due to the ability to simulate activities below wing level thus providing an unusual degree of realism.

We received very strong support for Chemical Hazard Assessment System (CHAS). The 50th Tactical Fighter Wing at Hahn AB asked us to leave the scenario and the computer system with them after the CPX just so they could practice more. General Donnelly, USAFE/CC, was very enthusiastic and asked that we provide the capability for every base to enhance their training. The General Officer Council was equally supportive, and we signed Program Management Direction within 7 weeks.

The initial direction is to provide the CPX capability for four bases within USAFE. At that time, the program will be reviewed to determine further direction.

The basic elements of a CPX are: a scenario of events that provides realistic information and tasking for the command post; a database that defines the location of people at any given time; a database that defines the facilities on the base and the type of protection they offer; and a means of dynamically evaluating the decisions and actions of the people in the command post. We had a computer simulation running in the back room that allowed us to keep the action going in real-time.

The advantages of CHAS are that it can simulate activities below wing level for a combined chemical and conventional attack. The accurate database allows the scenario to contain relevant mission events for the particular airbase conducting the CPX. It is not just a generic exercise. The computer provides the means to vary the defensive capabilities of the base as well as dynamic interaction due to battlestaff decisions. All of this provides the flexibility for the exercise to be reused indefinitely.

The present limitations of the system are that it is limited to an F-16 base and their type of missions. It is also limited to the threat that has been defined for USAFE and the associated hazard. Sortie generation is the present measure of merit for performance and is appropriate for a fighter base. For a MAC base some other measure of merit will be needed--perhaps ton-miles.

Additional uses for the computer simulation are that it can be used as an "electronic grease pencil" to record airbase damage and display it on a map of the airbase. It is also useful to dipict the contours of chemical contamination that would result from various weapons depending on agent type and weather. This would provide an increased understanding of the effects of chemical weapons.

The benefits to the R&D community are that through refinement of the operational concepts we can develop the equipment that is actually needed. We can lso refine the display characteristics to portray information in the most useful manner given the limited space in the command post. It would also enhance the user/developer interaction by having dialogs with bases that actually have a war-fighting mission.

The preliminary estimate of the cost per base to provide the CPX capability is $260,000. This is broken down into $100K for the facility database; $50K each for the personnel database, the mission scenario and conducting the CPX once; the computer system is an additional $10K.

The milestones associated with the program are that we expect to begin data collection at the first airbase in September 1987 with the CPX being held in March 1988. The second airbase would begin data collection in December 1987 with the CPX in July 1988. The third airbase would begin data collection in March 1988, and the CPX would be in September 1988. By the second quarter of 1989 the Fixed-Site Detection and Warning System integration contractor is expected to be on-board and would manage all further efforts as part of the overall effort.

Our future plans are to develop a similar CPX for other theaters such as PACAF, other missions such as reconnicense, and other commands such as MAC. We hope to develop self-help methods that will allow bases to accumulate the data needed by themselves. This will speed the implementation time. We also expect to provide the results of the exercises to the Fixed-Site program to improve its capabilities.

ASSESSMENT OF THE CHEMICAL CONTAMINATION DENSITY BY MEANS OF LIQUID DETECTION PAPER

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ABSTRACT

In the determination of Detection, Identification and Warning (DIW) system capability, special consideration must be given to detector discrimination capabilities, sensitivity, range of agents, the ability to provide rapid airbase screening, location of contaminated area, and discrimination between personnel and material contaminated to different degrees. This will facilitate decisions on posture reduction, replacement of Individual Protective Equipment (IPE), decontamination, and Collective Protection (CP) processing.
Liquid detection devices can be employed both pre- and post-attack. When employed post-attack, they are succesful only as long as free liquid is present. When the surface is very sorptive, e.g. concrete, it is difficult to detect liquid, even immediately after the attack. When liquid detection devices are employed pre-attack, present procedures allow only for determination that chemical agents are present, with little discrimination as to the extent and severity of the contamination. Currently-fielded liquid detection devices are M-8 and M-9 paper, while the Automatic Liquid Agent Detector (ALAD) and the Surface Contamination Monitor (SCM) are projected for the 1990 time frame. To obtain more information about the base wide distribution of contamination densities, the relation between detection device sensitivity and contamination density needs to be defined. For paper detection devices this would include correlation between spot patterns and contamination density.

For all these liquid detection devices the relationship between detector placement (quantity, location), expected pattern detected, and actual pattern disseminated needs to be defined. To do this, a statistical analysis of the expected detection device operation as a function of the contamination density for several attack scenarios is required.

A simple and efficient rule for the assessment of chemical contamination after an attack on an airbase with thickened chemical agents has been formulated in terms of drop patterns on detection papers. This rule which has been inferred from calculations on attack scenario's of an airbase can be applied to individuals and materials provided both are supplied with detection papers. Some examples will be given how procedures can be facilitated using the rule.

1. INTRODUCTION

There is a need for rapid air base screening for contamination after a chemical attack so as to locate contaminated areas and equipment in order to be able to exert contamination control efficiently. Moreover, if it would be possible to get quantitative information on contamination densities on surfaces of materiel or on personnel, then a discrimination between materiel and personnel contaminated to different degrees would enable decisions to be made on protective posture reduction, replacement of Individual Protective Equipment, and the need for decontamination. This could also be extremely useful in Collective Protection Processing by separating lightly and heavily contaminated personnel and treating them differently before admitting them to a Toxic Free Area.

We have therefore looked into the possibilities offered by existing means of detection and those that may enter service in the not too distant future. Most Nato Air Forces are equipped with liquid detection papers. They can be employed both pre- and post-attack. In the latter case the surface is blotted with the paper and if stains are present the information obtained is that a chemical warfare agent is present. However, only a very rough indication of the contamination can be obtained. With detection papers employed pre-attack present procedures allow to confirm the presence of chemical warfare agent only without any indication about the degree of contamination.

Liquid agent detectors (like the U.S. development ALAD which is planned to enter service in the 1990's) are also designed to give confirmation of the presence of agent but do not give quantitative information on the contamination density.

We have investigated whether the information that can be obtained by using detection papers pre-attack can be used for reliable estimates of contamination densities on air base substratum and personnel and if this would facilitate the making of appropriate decisions by the commander.

To obtain more information from liquid detector papers than present procedures allow, the relation between observed pattern of stains and contamination density has to be known. Therefore, a statistical analysis of the expected detector response as a function of the contamination density for several attack scenarios has been carried out.

2. METHODOLOGY

For the calculation of the dispersion of liquid drops in the atmosphere, the computer program CHEMATT, developed at our laboratory was used (1). This program is based upon a tilted Gaussian Plume model, in which the trajectory of a drop is represented by a line whose slope is determined by the ratio of wind speed and the free fall velocity of the drop. As a result of turbulent diffusion in the atmosphere there will be a distribution of drops with the same free fall velocity around this line. It is assumed that this distribution is normal with a standard deviation dependent on atmospheric conditions. The model is essentially the well-known Cramer-model (2), further extended by introducing a correction for the so-called crossing trajectories in order to describe the dispersion of large droplets more accurately.

The CHEMATT model does not take into account evaporation during dissemination nor the evaporation after landing on the ground. The latter is not required for our problem. The evaporation during dissemination can be partly accounted for by using an effective payload for the weapon considered.

The CHEMATT program has as a special feature an impaction model which

allows the calculation of droplets on a man or on a detection paper. The droplet distribution on detection paper can be plotted so as to give a picture of what a detedtor paper would look like. CHEMATT like any other simulation program needs input data. In our studies we simulated two types of attack on an airbase (dimensions 2 by 3 km): one with chemical bombs and one with a missile with a chemical warhead. This would give two different droplet distributions.
For the purpose of this study it is not necessary to use a large number of attack scenarios and we have limited ourselves to:

- an attack with ten bombs, each with a payload of 60 kg exploding at distances of 25 m at a height of 400 m
- a missile attack with a payload of 500 kg which is disseminated at a height of 1000 m.

Wind speeds have been varied between 2.5 and 7.5 meters per second and the wind direction has also been varied relative to the main axis of the airbase.
All computations have been repeated at various stability conditions of the atmosphere (Pasquill classes).
The output of CHEMATT consists of continuous contour plots of contamination density on the airbase. An example of such plots is given in Figure 1.
Furthermore, CHEMATT provides plots of detection papers showing stains caused by different drop sizes depending on the place where the detector paper was assumed to be. (Fig. 2). The size of the detector paper is variable but the default value is 75 x 50 square millimeter, which is the standard size of the M8 or M9 paper.

In order to relate drop size to the stain on the paper one needs data on the spread factor. We have measured the spread factors for the M8 and M9 papers in our laboratory. Figure 3 shows the relation between drop size and size of the stain on the paper for the M9 paper for thickened and unthickened mustard gas, in comparison with some data from literature (3). There is a systematic difference between the two sets of values. In all our computations we have used our own measured values. It will become clear later on that this difference will not influence the conclusions of our analysis.

An aspect that has not yet been dealt with is that of statistics. When a certain number of drops of a given size is expected to fall per unit area, then there is a certain probability that this number will indeed fall on the detection paper. For example if on the average 1.5 drops are expected to land on the detection paper, the chance to find no spots at all on the paper is 22 %, the chance of one spot is 34 %, of two spots is 25 % and of more than two spots is 19 %. CHEMATT also provides the statistics of the detection of liquid drops on the paper which allows to say something about the accuracy of the determination of contamination densities.

Fig. 4 shows the expected number of drops on the detection paper as a function of downwind distance for the case of an attack with a stick of eleven bombs. It shows clearly that at short downwind distances where the contamination density is high in terms of weight per unit area but the number of drops is small (large drop sizes), one may find 2, 1 or no drop at all on the detection paper. According to probability theory for a chance of at least 90 % to find two or more drops on the paper, the average expected number should be at least 2.3.

Especially in the area of high contamination densities one cannot rely on the information of just one paper. This conclusion becomes in particular of importance if one tries to use the information for discrimination between lightly and heavily contaminated personnel or for decisions about the necessity for clothing replacement.

3. ESTIMATION OF AIRBASE CONTAMINATION DENSITY DISTRIBUTION

Two cases have been considered for the placement of the detection papers on the airbase (see Fig. 5).

a. Liquid detection papers are placed on the corners of a grid with sides of 50 x 50 meters

b. Liquid detection papers are placed every 50 meters on the sides of a grid of 200 x 200 meters.

In order to evaluate the contamination contours the relation between spot patterns and mass per square meter must be determined. For that purpose we have used drop cards as depicted in Figures 6A and 6B. As an example Figure 7 shows the reconstruction of contamination density contours from detection papers after a missile attack for the case of a grid of 50 x 50 meters.
The number of detection papers to be analyzed can be reduced by a factor of two if the coarser grid is used. Although the finer grid produces more accurate results the contamination contours can still be located. An example of a reconstruction with the coarser grid is given in Figure 8.

A further reduction in the number of detection papers to be analyzed can be obtained if ALAD's are positioned on the base. Our estimation is that if one ALAD is placed on the corner of the squares with sides of 200 meters then, if the wind speed does not exceed 5 m/s, ALAD will always detect liquid drops. This means a total of 176 ALAD's on the base. If the ALAD detects liquid drops it sends a signal to the central unit. This information allows to select the detection papers to be analyzed.
Still the effort involved is substantial. We have made an estimate of the time and personnel needed to pick up the papers and analyze them. Without going into detail our result was that one needs at least 15

people and that it takes about 1.5 hours at least to reconstruct the contamination density contours. However, it should be borne in mind that no other method exists today to obtain quantitative information on contamination densities.
Some speeding up of the process could be obtained by the use of automatic pattern recognition techniques but the most is probably to be gained by the combination with the possibilities offered by modern information technology. This would imply continuously feeding meteorological data into a computer which is programmed to provide progressively more accurate estimates the more information such as provided by ALAD and by analysis of detection papers gets in.

4. CONTAMINATION OF INDIVIDUALS

The objective is to find a method for screening individuals which are about to enter a Collective Protection Facility for their level of contamination and/or indicate the necessity for clothing replacement. Heavily contaminated persons should first decontaminate to reduce the vapour load on the CPF.
The reconstruction of contamination contours showed that large differences (up to a factor of two) may occur between the contamination on any paper and the average deposition of agent in the area where the paper is applied. Therefore, it is not very useful to have an exact but laborious method for the determination of the amount of liquid on a detection paper from its spot pattern. We preferred a quick rule of thumb, easy to apply and not completely accurate but not introducing larger errors than we already have.
Starting point in our analysis was that we wanted to discriminate between persons with contaminations of more or less than 1 gram per square meter. From Figures 9 and 10 it can be derived that the limit of 1 g/sq.m is exceeded if:

- one or more drops of 1.7 mm

  or

- two or more drops of a diameter larger than 0.6 mm

are detected.
The norm of 1 g/sq.m is depicted in Fig. 9. There will always be a distribution of contamination density and consequently contaminations exceeding 1 g/sq.m will be found at distances between 425 and 480 m. In this downwind range a certain fraction of the exposed individuals will in reality be contaminated to slightly less than 1 g/sq.m. The rule of thumb works as depicted in Fig. 10. There exists a certain probability of find detection papers that follow the rules at downwind distances of 300 to 760 m. As a result false-negative and false-positive judgements may be made. So the Expectation based on the detection papers will differ from the Reality.
In practice random processes will determine the appearance of the spot pattern on a particular detection paper, see Fig. 4. This is called Chance. All three aspects may be judged in a positive or negative way:

	negative	positive
Reality	Clean	Dirty
Expectation	Innocent	Guilty
Chance	Acquitted	Convicted

The common scheme for analysing the numbers of negative, positive, false-negative and false-positive has been performed (three fold alpha-beta probability analysis).

Table 1 and Figure 11 provide the information for the case of an attack by a missile. A simulation sample size of 450 persons with one detection paper each was considered. Some observations from Table 1 are:

- 5 % of the total mass is on Clean persons so the Norm of 1 g/sq.m is adequate
- 43 % of the mass is on persons (97 of them) that are Dirty (more than 1 g/sq.m) but are Acquitted (and consequently not sent to decon)
- 55 % of the mass is on persons (113 of them) that are Dirty but Expected to be Innocent (the Rule is too optimistic)
- for 80 persons, carrying 34 % of the mass, the outcomes of Chance and Expectation are different, indicating that accidental effects are important
- 54 % of the mass is on persons that are sent to decon before admission to the CPF
- 14 persons are decontaminated although they are clean.

The overall picture is not so good. Too many misjudgements are made in both directions. However, it is already common practice in some NATO countries to use more than one, e.g. three detection papers, per man. The results for Expectation will not change in this case but those for Chance do change. For Chance to give a positive decision only one of the detection papers needs to meet the rule. Table 2 and Figure 12 give the results in the case of three detection papers and again for a missile attack.
One now observes that:

- 15 % of the mass is on persons (35 of them) that are Dirty but Acquitted
- 94 persons are Convicted by Chance, contrary to Expectation whereas the opposite only holds for 2 persons
- almost 84 % of the mass is now on persons (213 of them) that are sent to decon
- 22 persons are decontaminated although they are clean.

Similar simulations have been carried out for an attack with ten bombs. The results for three detection papers per individual are shown in Table 3. By adding the 'Convicted' cases one can see that now almost 95 % of the mass is regained.
It can be stated that the Rule presented will give satisfactory results. The benefit of the application of this rule is that the CCA is challenged with less than 1 gram per man. The penalty associated with this rather crude approach is that a relative small number of persons is sent incorrectly to decont. We estimate that the number of them will not exceed 5 % of the total population contaminated.
Relative large samples of the population in the areas have been used in the calculations (450 and 1100). In practice the fraction of airbase personnel in the open will be limited to about 15 %. They will be distributed over the airbase and surroundings.
If one realises that only a relatively small part of the airbase will be contaminated to more than 1 g/sq.m, then the number of men that have to be screened will be small, our estimate being at most a 100. An overall misjudgement of 8 % (see Fig. 12) seems therefore acceptable.

5. NBC CLOTHING REPLACEMENT

Additional information can be obtained from the calculations if a relationship is established with the protection time offered by the NBC suit against agents. We have measured the protection time for mustard agent as a function of drop size with different spatial distributions on the samples.
The results are summarized in Table 4. On places where there is a close contact with the skin the protection time is limited to about three hours if the drop size is larger than 5 mg. Those drops are detected with 95 % probability by the detection paper so this yields an indication that the NBC suit has to be replaced within about three hours.

6. CONCLUSIONS

Liquid detection papers can provide more information than just the confirmation of the presence of an agent. From analysis of the spot pattern one can obtain an indication that the NBC suit needs to be replaced within three hours after contamination. This decision can be made with 95 % certitude.
Detection papers can be deployed on an airbase in anticipation of a CW attack to assess contamination density contours. The proposed grid consists of squares with sides of 200 meters and detection papers located every 50 meters on the sides. The simultaneous deployment of ALAD's reduces the search to the most revealing papers but still the effort involved in retrieving and analyzing the detection papers remains substantial.
A simple and efficient rule has been formulated to assess the chemical contamination of individuals. The application of this rule assures rapid screening of individuals but to obtain sufficient accuracy it is necessary that the individual wears at least three detection papers. This procedure allows for a substantial reduction of the contamination brought into the CCA if those individuals whose contamination exceeds a given level are decontaminated first.
Automated pattern recognition of detection papers combined with modern information technology could enhance the screening process considerably. Therefore, it is recommended that this possibility be further investigated.

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AFAMRL-TR-85-026, Jaycor, Fairborne, Ohio

Table 1 Results of one detection paper per individual (a)

Reality	Expectation	Chance	Number of persons	Fraction of mass (%)
Clean	Innocent	Acquitted	207	2.2
Clean	Innocent	Convicted	8	1.1
Clean	Guilty	Acquitted	2	0.4
Clean	Guilty	Convicted	6	0.8
Dirty	Innocent	Acquitted	70	32.5
Dirty	Innocent	Convicted	43	22.1
Dirty	Guilty	Acquitted	27	10.4
Dirty	Guilty	Convicted	87	30.6

(a) Calculations performed for an attack scenario with one missile

Table 2 Results of three detection papers per individual (b)

Reality	Expectation	Chance	Number of persons	Fraction of mass (%)
Clean	Innocent	Acquitted	201	1.5
Clean	Innocent	Convicted	14	1.8
Clean	Guilty	Acquitted	0	0
Clean	Guilty	Convicted	8	1.1
Dirty	Innocent	Acquitted	33	14.0
Dirty	Innocent	Convicted	80	40.6
Dirty	Guilty	Acquitted	2	0.8
Dirty	Guilty	Convicted	112	40.2

(b) Calculations performed for an attack scenario with one missile

Table 3 Results of one detection paper per individual (a)

Reality	Expectation	Chance	Number of persons	Fraction of mass (%)
Clean	Innocent	Acquitted	257	1.8
Clean	Innocent	Convicted	185	1.9
Clean	Guilty	Acquitted	4	0.1
Clean	Guilty	Convicted	203	3.1
Dirty	Innocent	Acquitted	47	3.3
Dirty	Innocent	Convicted	104	10.0
Dirty	Guilty	Acquitted	2	0.3
Dirty	Guilty	Convicted	438	79.5

(a) Calculations performed for an attack scenario with ten bombs

Table 4 NBC clothing replacement
Preliminary results US clothing

Drop size	Protecting time (hours)	
mg	Close contact	Spacing
20	3	4-6
15	3.5	6
10	3-4	> 6
5	3-4	> 6
> 5	> 95 % probability of drop on LDP	

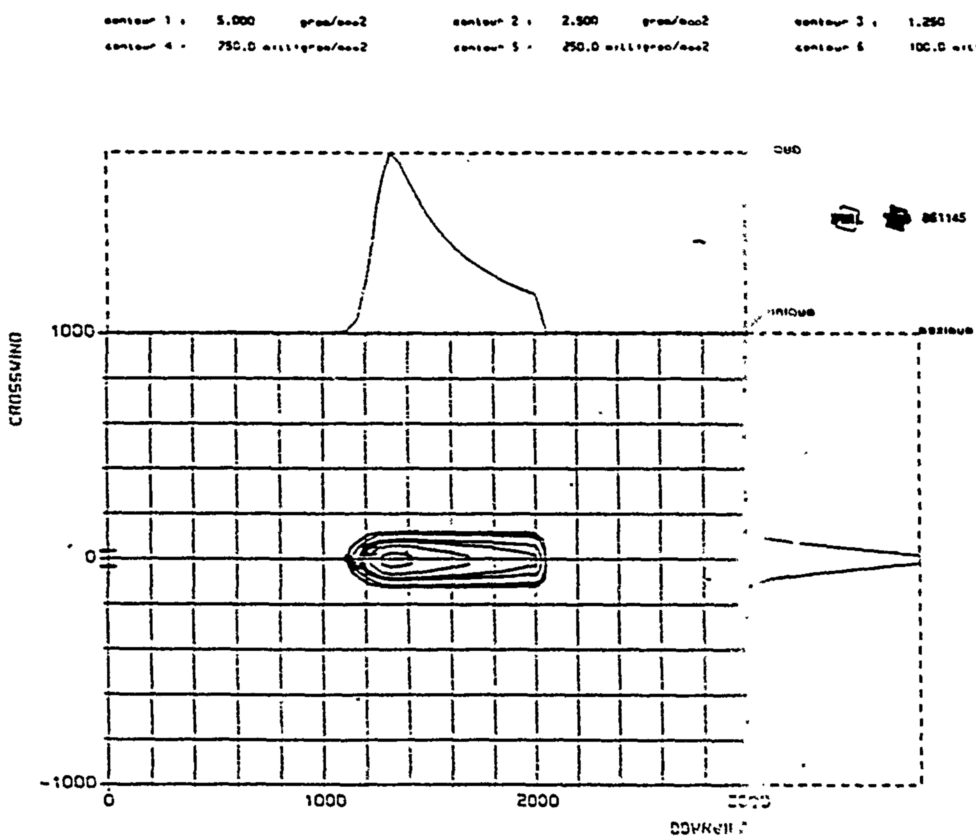


Fig. 1 Deposition on airbase; one missile; wind sp‑‑d 5 m/s

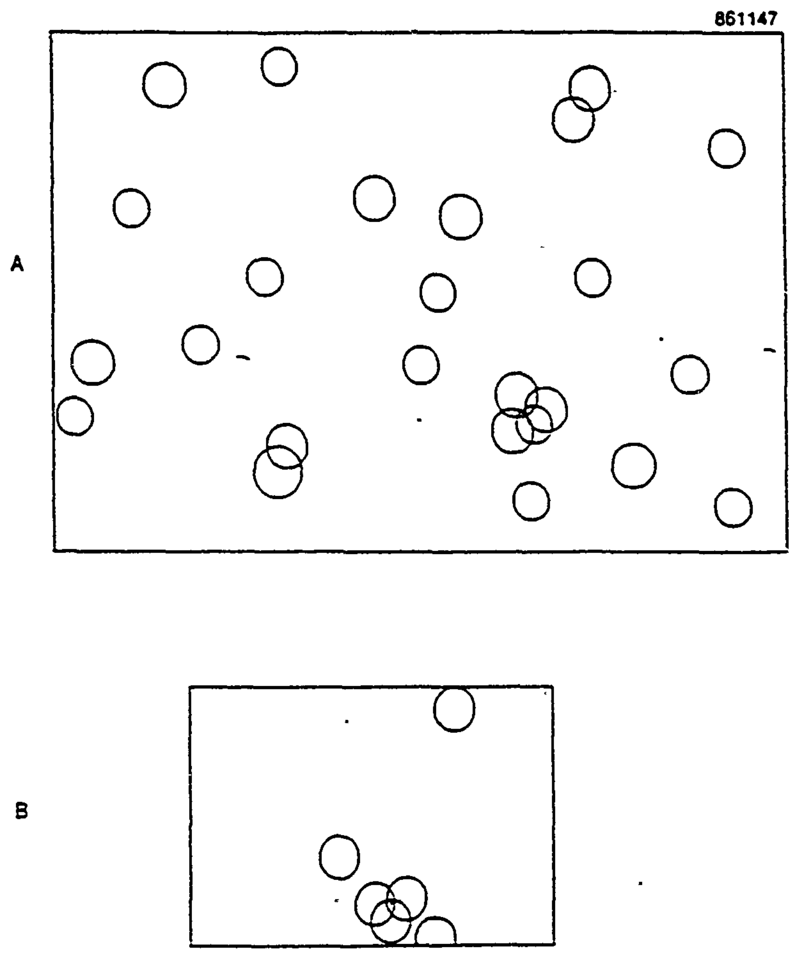
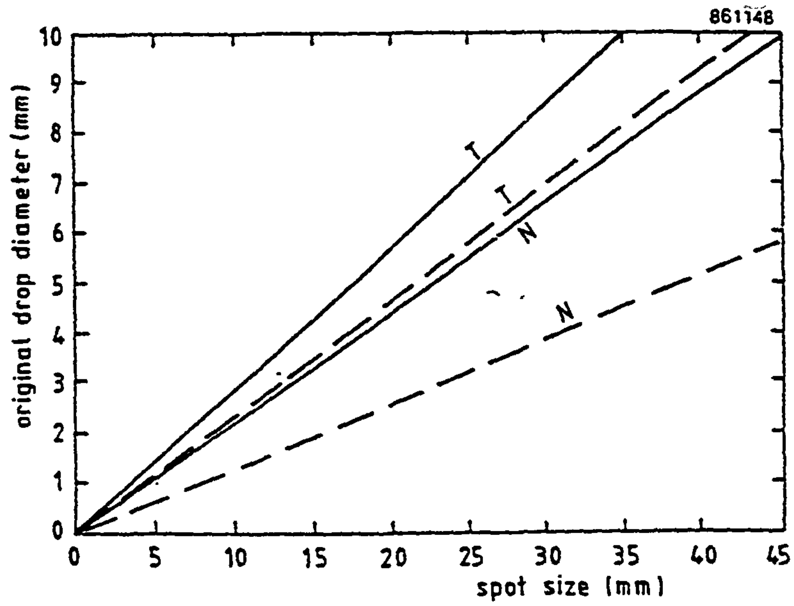


Fig. 2 Computed detection papers, large and standard formats



T = Thickened agent

N = Neat agent

- - - - = Values from ref. 3

——— = Values from experimental work, performed at PML-laboratories

Fig. 3 Relation between drop diameter and spot size

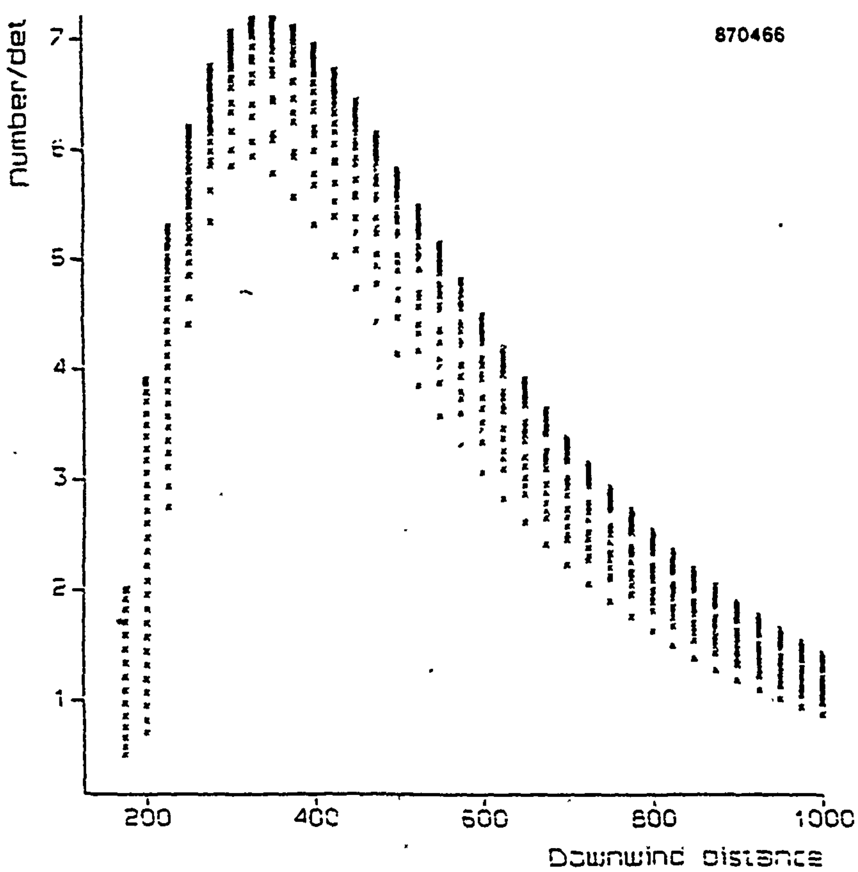


Fig. 4 Drop count vs. downwind distance

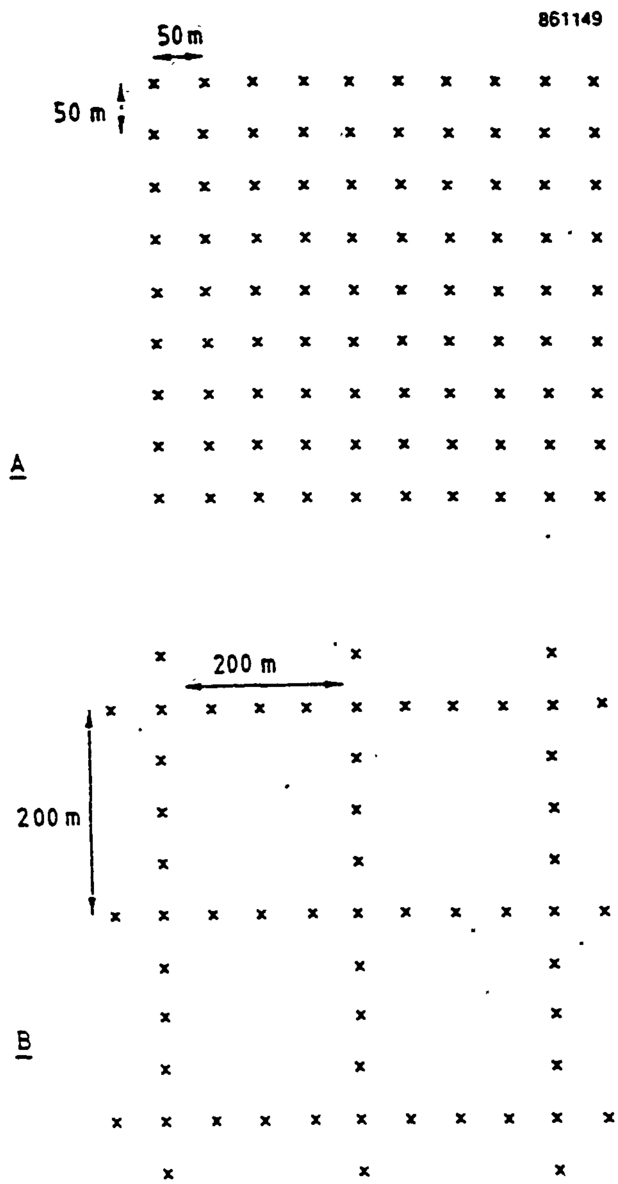


Fig. 5 Grids of detection papers

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MASS=	0.100	DROP=	0.537	SPOT=	2.31
MASS=	0.200	DROP=	0.677	SPOT=	2.91
MASS=	0.300	DROP=	0.775	SPOT=	3.33
MASS=	0.400	DROP=	0.853	SPOT=	3.67
MASS=	0.500	DROP=	0.919	SPOT=	3.95
MASS=	0.600	DROP=	0.977	SPOT=	4.20
MASS=	0.700	DROP=	1.03	SPOT=	4.42
MASS=	0.800	DROP=	1.07	SPOT=	4.62
MASS=	0.900	DROP=	1.12	SPOT=	4.81
MASS=	1.00	DROP=	1.16	SPOT=	4.98
MASS=	2.00	DROP=	1.46	SPOT=	6.27
MASS=	3.00	DROP=	1.67	SPOT=	7.18
MASS=	4.00	DROP=	1.84	SPOT=	7.90
MASS=	5.00	DROP=	1.98	SPOT=	8.51
MASS=	6.00	DROP=	2.10	SPOT=	9.05
MASS=	7.00	DROP=	2.22	SPOT=	9.53
MASS=	8.00	DROP=	2.32	SPOT=	9.96
MASS=	9.00	DROP=	2.41	SPOT=	10.4
MASS=	10.0	DROP=	2.49	SPOT=	10.7

Fig. 6A Relation between drops and paper stains

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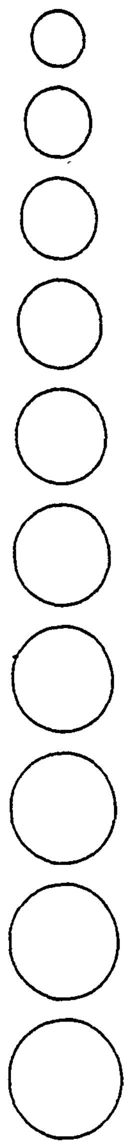


MASS=	10.0	DROP=	2.49	SPOT=	10.7
MASS=	20.0	DROP=	3.14	SPOT=	13.5
MASS=	30.0	DROP=	3.60	SPOT=	15.5
MASS=	40.0	DROP=	3.96	SPOT=	17.0
MASS=	50.0	DROP=	4.27	SPOT=	18.3
MASS=	60.0	DROP=	4.53	SPOT=	19.5
MASS=	70.0	DROP=	4.77	SPOT=	20.5
MASS=	80.0	DROP=	4.99	SPOT=	21.5
MASS=	90.0	DROP=	5.19	SPOT=	22.3
MASS=	100.	DROP=	5.37	SPOT=	23.1

Fig. 6B Relation between drops and paper stains

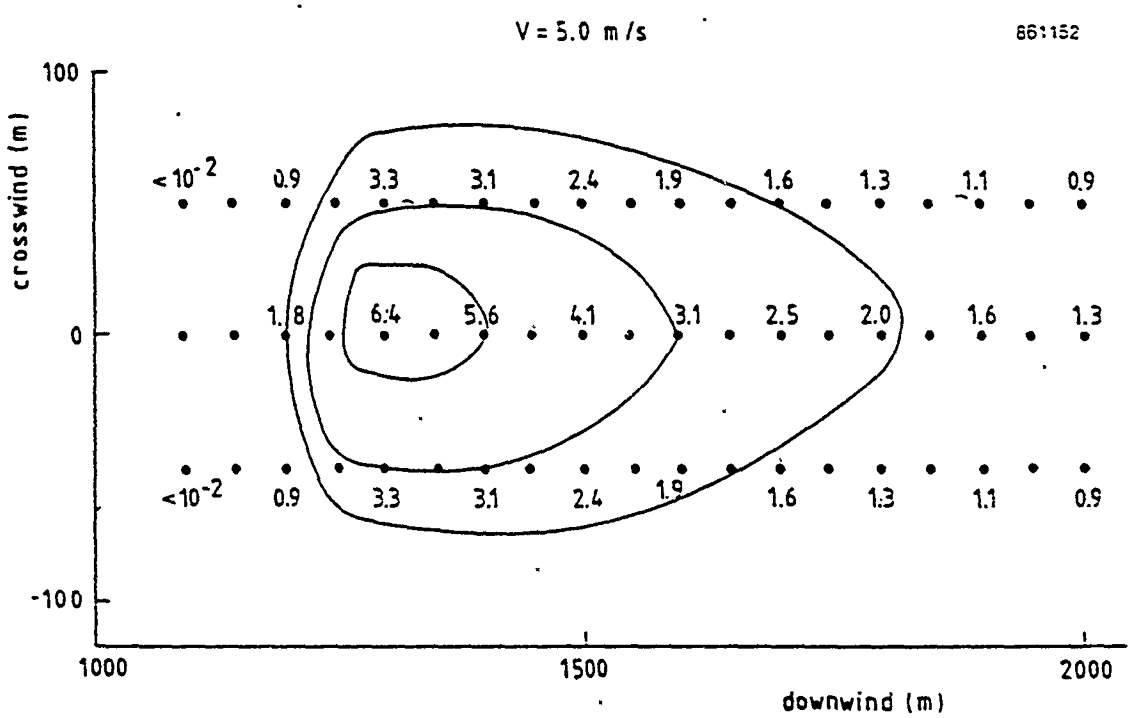


Fig. 7 Reconstruction after a missile attack of the contamination contours from detection papers. The grid used, is the square with sides of 50 m.

Wind direction : W

Wind speed : 5 m/s

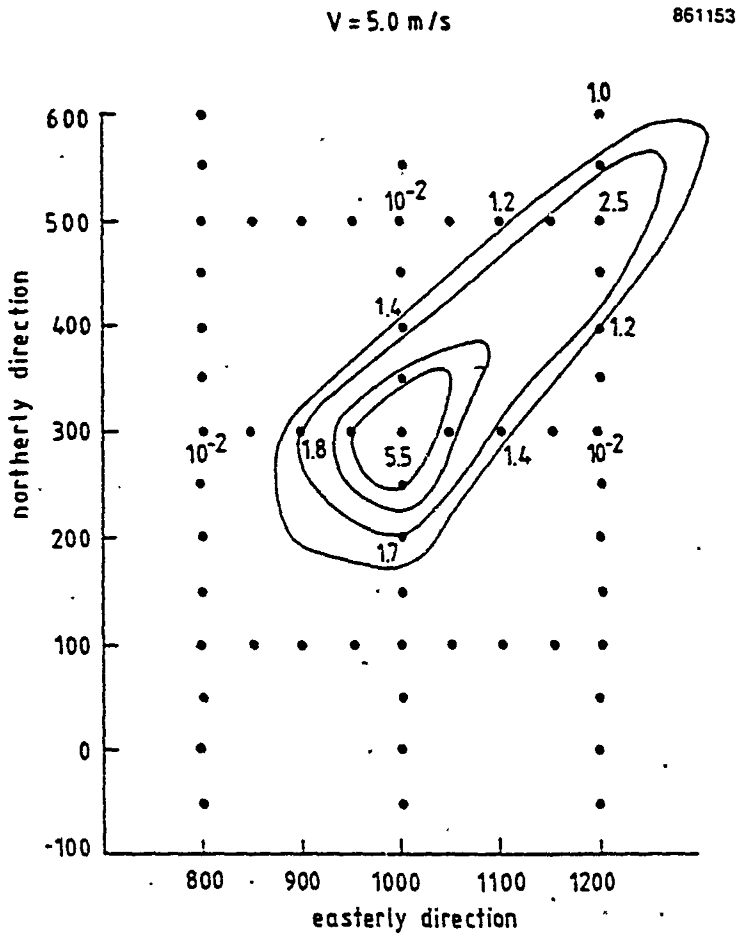


Fig. 8 Reconstruction after a missile attack of the contamination contours from detection papers.
The grid consists of squares with sides of 200 meters; detection papers are on the sides every 50 meters.

Wind direction : SW

Wind speed : 5 m/s

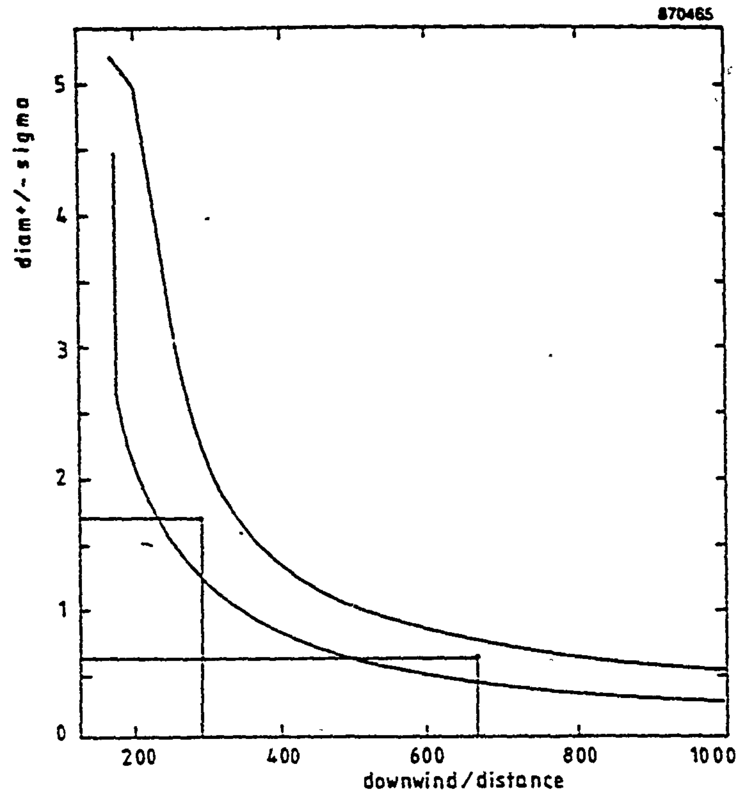


Fig. 9 Drop diameter vs. downwind distance

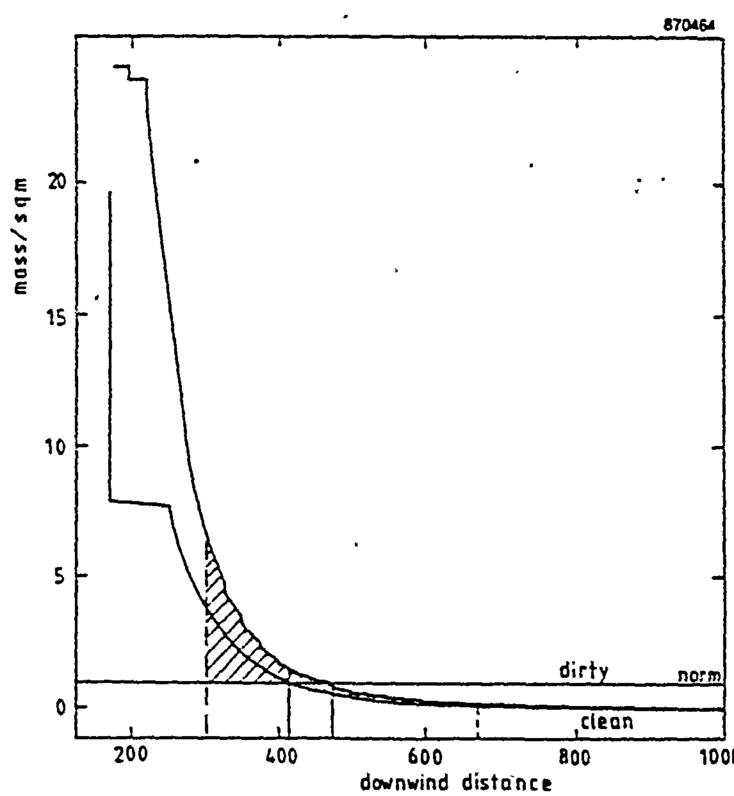
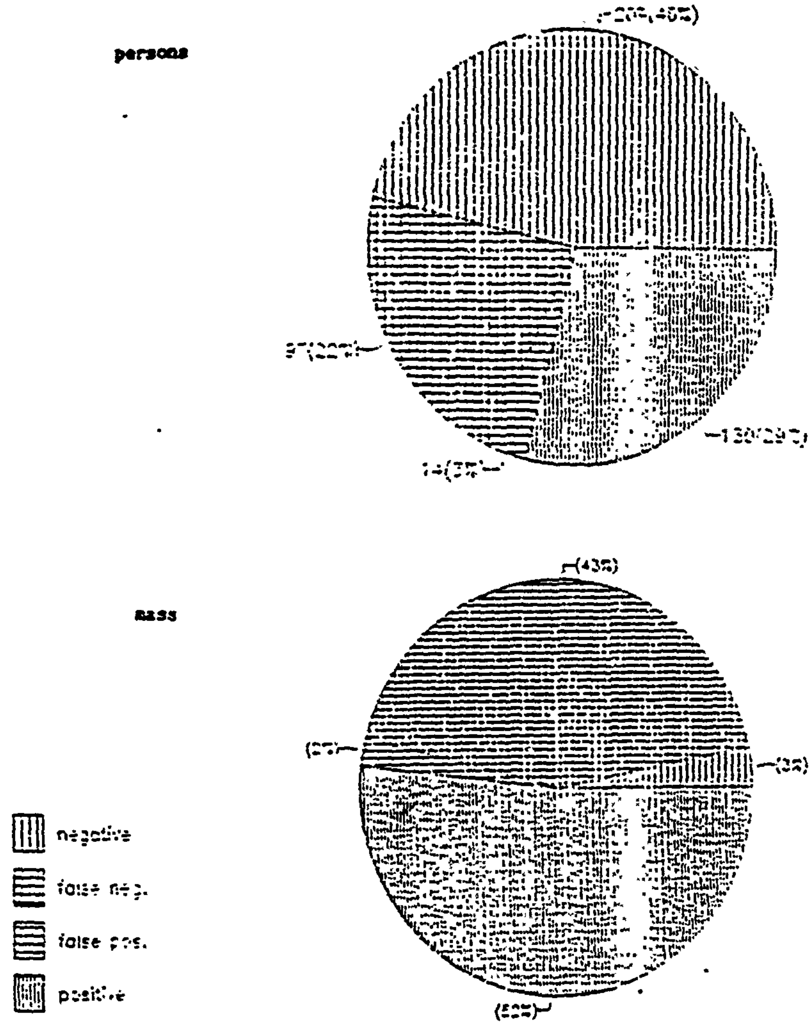


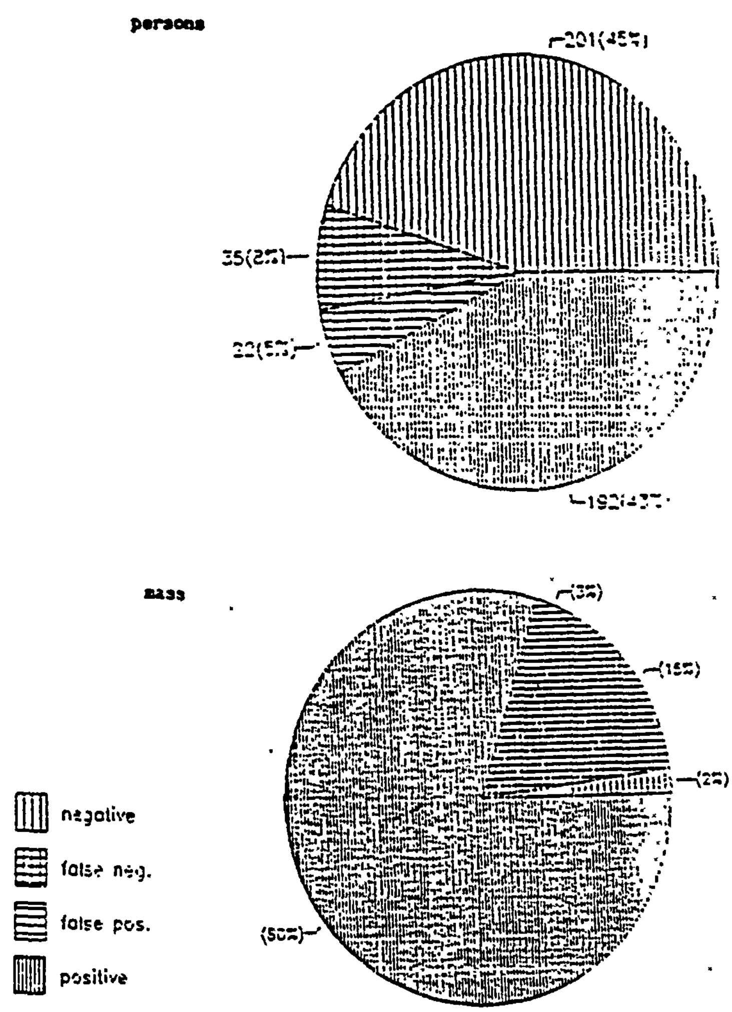
Fig. 10 Contamination density vs. downwind distance



positive = Convicted = selected for decon

false = Selection contrary to actual contamination level

Fig. 11 Effects of selecting individuals using one detection paper



positive = Convicted = selected for decon

false = Selection contrary to actual contamination level

Fig. 12 Effects of selecting individuals using three detection papers

U.S. Army NBC Reconnaissance Program

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The U.S. Army has identified serious deficiencies in current methods of providing battlefield commanders with timely and accurate nuclear-biological-chemical (NBC) data. Current systems are rudimentary (e.g., chemical detector paper on a stick), labor intensive, slow, and require the crew to dismount into potentially contaminated areas to conduct NBC reconnaissance. The data and sample collection operation is such that a serious lag occurs between the collection of data, its analysis, and the transmission of information to the ultimate users.

Due to the dynamic nature of future battlefields, timely and accurate NBC information provided by a dedicated NBC reconnaissance system will be extremely important for tactical decision-making by area commanders. The threat of NBC contamination on future battlefields is high, and the U.S. Army will need a fully integrated NBC reconnaissance system to rapidly provide the necessary NBC information that can favorably affect tactical outcomes on the battlefield. The needed NBC reconnaissance capability must allow military units to collect and report information faster and more accurately, but must also be able to move with conventional reconnaissance elements on the battlefield.

The U.S. Army Chemical Research, Development and Engineering Center (CRDEC) and the U.S. Army Chemical School initiated the NBC reconnaissance system (NBCRS) development program in 1985 (Milestone I, 23 May 1985) to meet the Army's requirement for a standardized, dedicated NBC reconnaissance capability. The initial phase of the NBCRS development was an extensive Concept Evaluation Program (CEP) to fully define the feasibility of conducting NBC reconnaissance and to provide data which could be used as the basis for designing the U.S. Army's NBCRS. The CEP indicated that mobile NBC reconnaissance was possible with the existing force structure in the Army and that it was possible to perform NBC reconnaissance as part of conventional reconnaissance on the modern battlefield. Mock-ups and systems integration efforts performed as part of the CEP also indicated that it was technically feasible to perform the required NBC reconnaissance tasks from a mobile platform and provided extensive insight into the remaining design challenges involved to meet the need.

A portion of the CEP program also evaluated the Federal Republic of Germany's TPz-1 "FUCHS", which was configured to perform NBC reconnaissance. The FUCHS is a six-wheeled, amphibious, armored cargo and tactical transporter. The NBC reconnaissance version of the FUCHS had three on-board computers, a position locator system, and special detection and identification equipment for both nuclear and chemical hazards. The FUCHS was evaluated by CRDEC and U.S. Army Chemical School personnel during Feb - May 1986. The FUCHS was found to offer definite advantages over existing U.S. Army NBC reconnaissance capabilities but was not found to fully meet the NBCRS requirements. Actions are currently on-going within the U.S. Army to fully ascertain the advantages of obtaining the NBC configured FUCHS vehicle as an interim NBC reconnaissance capability for the U.S. Army.

The XM87 NBC Reconnaissance System (NBCRS) development program, currently in Full Scale Development (FSD), has evolved from the CEP to fully satisfy the U.S. Army's urgent need for a standardized reconnaissance system capable of detecting, identifying, correlating, and disseminating accurate and timely NBC information to area combat commanders on the battlefield. This system will also provide the capability to collect and store samples of unknown material for later analysis by designated laboratories and can physically mark contaminated areas on the battlefield.

To obtain the required NBCRS capabilities a host of detection systems, a position locating device, and communications equipment will be integrated through an on-board central data processing unit (CDPU) to provide formatted NBC reports over secure communications to area commanders on the battlefield. Both existing and developmental subsystems are being integrated into a cohesive package that will be installed in the M113A2 Armored Personnel Carrier (APC).

The XM87 is the first of a series of reconnaissance systems. The FSD program is scheduled to enter formal Government Developmental Testing (DT) in 3QFY88 with subsequent Operational Testing (OT) commencing in 2QFY89. Four prototype vehicles are currently being fabricated by the development contractor, TRW, Incorporated, Redondo Beach, CA. The XM87 will be type classified by the U.S. Army in 2QFY90, with the first six XM87 systems fielded in 3QFY92.

Follow-on pre-planned product improvement programs will provide NBC reconnaissance systems geared toward installation on a wheeled-vehicle derivative and Armored Family of Vehicles (AFV).derivative in the FY 90-94 timeframe.

The capabilities provided on the XM87 system include:

a. Central Data Processing Unit (Severe Environment Computer System: SECS-86, SAI 5000 Plasmascope display) - These commercially available systems will provide the necessary computing power to collect data from on-board subsystems, then correlate and present information to the operator on various aspects of NBC systems operation. The CDPU will formulate all data provided by on-board sensors and display the formatted NBC messages for the operator to review, modify and transmit through the communication system to area commanders.

b. Point and Standoff chemical agent detection:

(1) XM21 Remote Sensing Chemical Agent Alarm (RSCAAL) - This system is currently in FSD and will provide the XM87 with the capability to remotely detect nerve and blister agent vapors at a distance of up to 5 kilometers. The XM21 will be mounted on the exterior of the XM87 and will be protected from conventional battlefield hazards by means of a composite enclosure. This capability will provide the crew with early warning of contaminated areas in their vicinity.

(2) M8A1, Chemical Agent Alarm & XM22, Automatic Chemical Agent Alarm (ACADA) - The XM87 will utilize the existing chemical agent detection capabilities provided by the M8A1 to identify chemical agent vapors in the immediate vicinity of the XM87. This point detection capability will provide warning to the crew that the XM87 is in an area where a chemical agent vapor hazard exists. The M8A1 will eventually be replaced by the XM22, which is currently in development. The XM22 will provide an overall increase in detection sensitivity and provide the capability to quantify/identify chemical agent vapors.

(3) MM1 Mobile Mass Spectrometer (GEMS) - This German-made system will provide the XM87 with the capability to detect, identify, and quantify residual liquid agent contamination on the ground for all known chemical agents. The GEMS will also have the capability to detect unknown agents on the battlefield. The GEMS is extremely sensitive (HD, GD - .0001 mg, VX - 0.1 mg) and is currently used by the FRG on the NBC reconnaissance version of the FUCHS. A mechanized sampling system will be used in conjuction with the GEMS to pick up residual contamination from the ground and present it to the GEMS probe for analysis. The sampling system will utilize a set of mechanical booms that will drag silicone tubing on the ground behind the XM87 and periodically move the tube up to the GEMS for analysis.

(4) Chemical Agent Monitor (CAM) - This British-made monitor has recently been adopted for use by the U.S. Army and will be externally mounted to the XM87. The CAM will be used to identify nerve and mustard agents on the exterior of the vehicle to determine the extent of contamination after the XM87 has been exposed to chemical agents. This handheld monitor will also be used to assess the extent of contamination on equipment and crew prior to entering the XM87.

c. Nuclear detection: Radiac set (AN/VDR-2) - This sensor was recently (2QFY87) type classified by the U.S. Army and will be utilized as part of the XM87 for measuring gamma, neutron, and beta radiation dose rate. The AN/VDR-2 will be internally mounted but will be easily removable for dismounted use by the crew.

d. Mechanized surface sampling system - As mentioned above, this subsystem will be used in conjuction with the GEMS and primarily consists of two reels of silicone tubing, operated by a hydraulic manifold, that will automatically feed two booms on the exterior of the vehicle. The reels and manifold are contained within the vehicle (under the floor) and the booms are attached to the curb side rear of the XM87. The operator will be able to automatically control the function of the boom and reel assemblies from within the vehicle.

e. Contamination and clear lane marking system - This subsystem consists of contamination markers for marking nuclear, chemical, and biologically contaminated areas by means of NBC drop-set markers. Also, markers denoting clear lanes (or uncontaminated areas) will be part of this subsystem. Markers will be internally stored within the vehicle and will be manually deployed through a port in the XM87 tailgate.

f. Life Support System (LSS) - This subsystem of the XM87 will provide overpressure to the interior of the vehicle while at the same time supplying clean, uncontaminated air to crew masks and cooling vests. This system is being derived from many standard U.S. Army components which were developed as part of the hybrid collective protection system (HCPE). The ambient air filtering will be accomplished with two M48 gas-particulate filters, and crew comfort will be maintained in both hot and cold climates by integral heating and microclimate cooling components within the LSS. The conditioned air will be provided to crew member's protective masks and cooling vests through flexible hosing which will connect to the LSS, (similar to the crew cooling in the M1 Abrams main battle tank).

g. Sample collection and storage - To transport samples of unknown material for eventual analysis by a designated laboratory, the XM87 will provide the capability to store 24 samples on the exterior of the vehicle. This subsystem consists of four containers attached to the vehicle tailgate that can store 24, 50 cc vials of material for later analysis. By means of a glove port, the crew will be able to obtain and store samples without exiting the vehicle.

h. Digital burst communication (Radio sets AN/VRC46 & AN/VRC47, Communication Security Equipment) - The communications package will consist of standard military components and will provide the capability to communicate by digital and voice means. The communications package will be tied to the CDPU for digital burst transmission of NBC messages. Voice communication will be through the standard touch-to-talk microphone on the AN/VRC 47 radio. Communications security equipment will be an integral part of the communication package.

i. Modular Azimuth Positioning System (MAPS) - This system will provide position locating data for the crew. The MAPS is currently being developed by the U.S. Army to provide accurate position locating data to many different Army tactical systems. The MAPS displays grid coordinates to the operator to accurately pinpoint the XM87 location on the battlefield. MAPS accuracy is better than 2 percent of distance travelled, which allows for NBC reporting that will accurately identify contaminated areas to friendly troops on the battlefield. The system includes three components, the Dynamic Reference Unit (DRU) which contains the inertial guidance system. Vehicle Motion Sensor (VMS) adapts to the speedometer/odometer and provides distance information, and the Control and Display Unit (CDU) which provides position information to the operator and is the means to control the MAPS functions.

The XM87 is being designed to accommodate four crew members, but can be operated effectively by three. Six XM87's will be located in the NBC reconnaissance platoon at each heavy division and armored cavalry regiment chemical company in the U.S. Army. Also, two XM87's will be allocated to LA teams in each separate brigade. These dedicated NBC reconnaissance assets will be utilized by the Army to conduct specialized reconnaissance in support of division or corps operations throughout the depth of the battlefield.

Potential application of NBCRS technology to airbase survivability and maintenance in NBC environment could include:

a. Rapid Runway Repair:

(1) Mobile capability for sampling, quantifying and marking contaminated areas for decontamination teams or area avoidance.

(2) Microclimate cooling and crew overpressure systems enhance probability of survival for maintenance personnel moving and working in contaminated environment.

b. Airbase Defense: The integrated NBCRS detector package could provide early warning of chemical attack and identify migration of nuclear contamination into operational areas.

Representing the Human as a Three-Dimensional Solid
For Personal Equipment and Design and Evaluation

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In response to new technological breakthroughs the U.S. Air force has initiated a research effort to develop a system which treats the human as a numerically measured three-dimensioanl solid in the design of persoanl equipment and workstations. The system is called the Three-Dimensional Anthropometric Computerized Evaluation System (3ACES). The effort includes the development of a new automated three-dimensional acquisition device capable of finely digitizing the entire surface of the human body in a matter of seconds. Also included is the development of computerized data analysis and design tools.

This information will improve our ability to design personal equipment, and it is possible that the digital information could also be used in the manufacturing process. In addition, since the acquisition device will be capable of digitizing the surface of an equipped person, it should enable designers to design for intergration of equipment such as helmet/mask ensembles, and equipment/workstation systems. Furthermore, it will allow computerized evaluation of equipment, improving our ability to identify the source of fit and integration problems.

In this paper the 3ACES research effort will be described and application methods will also be discussed.

MCU-2/P CHEMICAL BIOLOGICAL MASK PROGRAM

by

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25 Aug 87

This paper will be a review of the MCU-2/P chemical/biological mask program. It will briefly describe the purpose of the program, the background of the MCU-2/P development, a description of the mask, it's performance characteristics, and the current status. This MCU-2/P overview should provide a general understanding of the mask, how it works, and what the Air Force is doing to develop and procure this system.

The objective of the MCU-2/P program is to procure a new protective mask for USAF groundcrew personnel that will provide a 10 level of protection from chemical agents while improving visibility compared to current masks. The new mask must be available in sizes to fit USAF military personnel and mission essential civilians.

The USAF required a replacement for the M-17 series CD mask and participated in the XM-30 program which was initially an Army development. In 1982, the Army terminated the XM-30 program and the Air Force assumed management responsibility. Subsequently the Air Force redesigned the mask into the MCU-2/P. In September 1983, a competitive production contract was won by Scott Aviation, and the first MCU-2/P's were delivered the following year. In May 1985, an operational chemical defense exercise in Ramstein A.B., Germany (Salty Demo) was sucessfully supported by the MCU-2/P mask. To satisfy the additional Air Force requirements for the mask that had been identified in 1985, a second competitive contract was awarded to Mine Safety Appliance (MSA) in March 1986. The contract included an option to develop and produce an improved configuration of the mask. Because of shortfalls in inventory requirements as well as national exigency requirements identified by the Navy, additional actions were initiated for procurement of the currently configured MCU-2/P. This effort resulted in the awarding of competitive contracts to both Scott Aviation and MSA for the production of the mask. The dual award was an effort to produce the required amounts of masks in as timely a manner as possible. The Air Force and Navy have identified additional inventory requirements and follow on procurements will be full and open competition based on the technical data package provided by the program office.

The MCU-2/P mask is designed to protect groundcrew personnel's eye and respiratory system in a chemical/biological warfare environment. The MCU-2/P has a full-face polyurethane lens, a molded silicone facepiece, nosecup, and a drinktube. It includes polycarbonate plastic outserts to protect the lens from scratches and contamination, a CD hood that covers the head and shoulders for protection against liquid agents, two C-2 filter canisters, and a mask carrier case.

When used in its intended environment as a chemical/biological mask, survivability for the wearer of the MCU-2/P is high. The requirements for the current configuration of the mask is to meet the 10 protection factor for the 5th to 95th percentile of the Air Force population. The mask is not effective in an oxygen deficent atmosphere such as high altitudes because it is only a chemical agent particulate filtering mask. The MCU-2/P mask is compatible with the MAG-1 spectacles and is USAFSAM approved for those requiring corrective lenses. The full-face lens provides added visibility and increased comfort, as well as easier identification of personnel wearing the mask. The standard NATO C-2 canister can also be quickly changed while still providing adequate protection to the wearer.

Research and development is complete for the current configuration of the MCU-2/P, and the Air Force and Navy are currently on contract for production of this mask. The program office is also involved in the development of an improved configuration of the MCU-2/P. The improvements planned by MSA will be incorporated into the mask to improve the fit (through sizing), the lens material, and communications capability. The fit improvements incorporate an Air Force anthropometric sizing system which will give an improved face seal for 90% of the Air Force population. The new lens material will be more resistant to petroleum products, yellowing and scratches, and have less memory. Finally, the microphone will give an additional communications capability to the MCU-2/P mask.

The Air Force is currently managing two separate production efforts. The present production of the MCU-2/P by MSA, which includes the current configuration and future production of an improved configuration. The national exigency production of MCU-2/P's for the Navy and Air Force which was awarded to both MSA and Scott Aviation will begin deliveries in December 1987. The additional requirements for the current and improved configurations of the MCU-2/P will be accomplished by full and open competitive contract efforts.

THE IMPERMEABLE CHEMICAL DEFENSE SUIT (IMP)

BY

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OVERVIEW

This paper presents information about the Impermeable Chemical Defense Suit (IMP). Included are five areas: background, the IMP suit, design modifications, future efforts and summary. The background presents historical information on the program through which several iterations of design have been accomplished. The current IMP suit design is presented. Design modifications are described in terms of the condition that required improvement and what was done to correct the problem. Future efforts and summary show the direction envisioned for the program and strengths of the IMP design approach.

BACKGROUND

Requirement. To develop and procure systems that will provide better chemical agent protection from known and suspected agents than the current ensembles without increasing thermal burden or other restrictions. This program was directed by Congressional interest; there was no user initially.

Major Milestones Completed. In September 1982, a sole source contract was awarded to design, develop, test and produce prototype hardware for an impermeable, one-piece, totally encapsulating, reusable chemical defense ensemble for use in highly toxic environments.

The initial design evolved into a version of the suit made from white fabric. This was demonstrated in an Air Force Development Test and Evaluation in 1984.

A further improvement in several areas of the design was demonstrated successfully at the USAFE exercise, "Salty Demo," in Germany in 1985. Salty Demo was a full scale combat exercise with simulated chemical attacks and the IMP suit was utilized in a variety of tasks. Among the skill types that used and liked the IMP suit were: Explosive Ordnance Disposal (EOD), Integrated Combat Turn (ICT) personnel, munitions loaders, parachute riggers, rapid runway repair (RRR) personnel, and air traffic controllers.

The current phase of development was awarded in 1986 for the Continuing Development/Equipment Redesign (CDER) phase, as a modification to the sole source contract. The Critical Design Review was held in 1987 for this improved design.

A field decontamination study was also completed in 1987. This study showed that field decontamination is effective with the IMP suit.

The User, Explosive Ordnance Disposal (EOD). The EOD community became a user for the IMP suit in 1985, following Salty Demo. The U.S. Air Force wartime effort requires protection of sortie generation. EOD ability to clear runways and render safe unexploded ordnance (UXO)/munitions (chemical and otherwise) protects sortie generation by the U.S. Air Force.

Replacement for Existing Chemical Suit. The IMP suit replaces the Toxicological Agent Protective Suit (M3). Common problems with the M3 and other chemical protective gear are restriction of vision by gas mask; heavy, bulky, clothing that restricts air flow to cool wearer, and cumbersome boots. The M3 was designed many years ago. Several layers of heavy clothing are required in the complete M3 suit.

THE IMP SUIT

Figure 1 shows the IMP suit improved design from the 1987 effort. Highlights of this chart are: Water is readily available through the drink tube mounted in the clear visor. Communications passthroughs allow connection to standard field radios outside the suit. Emergency breathing systems with air drawn by lung power and a compressed air bottle are filtered at the front of the suit. A system of one-way dump valves on the back, arms, and lower legs keeps the internal air pressure at a comfortable, consistent level. There is a backpack blower motor for moving air into the suit.

Selected Features of the IMP Suit. This suit is designed for extended wear, much longer than current chemical suits. The Powered Air Purifying Respirator blows filtered air through the suit for circulation and wearer comfort. Meal pouches can be carried in pockets inside the suit. The wearer can withdraw his or her arms from the sleeves in order to eat food or adjust equipment within the suit. With a hands-free multi-channel radio, wearers can talk with other IMP suit wearers or with another communications network. There is no requirement to wear a mask with the IMP suit. The current configuration of the suit, with large transparent areas in the hood, has a wide field of vision forward, upward, downward, and to the rear. Figures 2 and 3 demonstrate the wide field of vision. The blown air keeps the visor clear, eliminates "fogging up." Field decontamination of the IMP suit is possible.

DESIGN IMPROVEMENTS

Mobility. Batteries are used to power the ambient air system. Lithium batteries require special transportation in accordance with DOT-E-7052. The IMP suit batteries are lightweight and compact. These lithium batteries were selected for their long term power supply (Figure 4). They have a BCX chemistry to permit intermittant use, for minutes or hours and being turned off and on several times. BCX lithium batteries do not produce harmful gasses; they are an improvement over the older sodium oxide lithium batteries, but all lithium batteries are covered by the same DOT regulation. However, an alternate approach, using rechargeable batteries, requires no special transportation arrangements. Although nothing in the U.S. Air Force inventory seems to be as compact and lightweight as the lithium batteries for the IMP suit, EOD teams can deploy rapidly with rechargeable batteries for their suits. The rechargeables provide short term, convenient power for deployment, training, or demonstrations of the IMP suit.

Backpack Fit and Comfort. The backpack only weighs 13 pounds but in the prototype suit and Salty Demo designs, the shoulder harness placed all the weight on the shoulder straps. This caused the shoulder straps to eventually cut into the wearer's shoulders and become uncomfortable. The chest strap was difficult to close at times. The improved design uses a modified camper's backpack frame. The weight is carried on the wearer's hips. The frame is adjustable to short and tall people. The belt crosses the stomach and is easier to reach and adjust. (Figure 5)

Optimal Air Pressure in Suit. Discomfort to the wearer's eardrums when straightening up from deep knee bends occurred in the prototype suit. The Salty Demo suit corrected the number and placement of one-way air valves. Now, the suit quickly expells surplus air and regains the correct pressure to prevent "popping" of the wearer's ears. (See Figure 1)

Water Access. The Salty Demo suit had one small water pouch in an interior pocket of the IMP suit. This was a limited water supply, too little for long wear of an impermeable suit. To use the water pouch, the wearer withdraws their arms from the sleeves to hold the water pouch. Once empty, there was no easy refill of the pouch. Now, the improved design IMP suit has a drink tube in the visor so that the wearer can drink from standard NBC canteens kept outside the suit. The wearer can drink as much water as there are canteens available. The wearer keeps both hands inside the sleeves while drinking.

Cuff. The cuff in the Salty Demo suit and earlier versions was rigid plastic. Its large ring enabled wearers to easily slip their hands into the gloves, but limited access in tight places. The clip type plastic cuff rings were hard to snap closed and properly attach the gloves. Now, an O-ring is fitted into a flexible groove, as shown in Figure 6. With a flexible cuff, wearers will be able to reach into those tight places, as the glove cuff molds itself in the shape of the wearer's wrist. When pressure against the cuff is released, the cuff pops back into its circular shape.

Comparison to an Existing Suit. The weight of an IMP suit versus an M3 suit is about the same. The IMP suit according to the specification cannot weight more than 30 pounds, exclusive of the optional air bottle.. An M3 suit, with its multiple layers of clothing and fireman's overboots, weighs about the same but is bulky and time consuming to don by comparison. With the IMP suit, visibility is enhanced. Vehicles can be operated with vision through the visor pieces to the side and rear of the IMP suit hood. Only limited vision is available with the M3 suit. Food, drink and liquid waste elimination is available with the IMP, but not with the M3. Identification of the wearer is relatively simple with the large visor area and no mask in the IMP. Identification is difficult with the goggle type eyes of the M3 hood and mask. This is important for security reasons, so that personnel are able to recognize wearers of chemical gear. Visibility into the hood is also vital to EOD personnel who work in closely coordinated team efforts. They must anticipate the next step to be taken by their teammate; knowing who is in the suit and how they operate is necessary. A further benefit from being able to see into the hood is the ability of a team member to recognize symptoms of heat stress, since EOD personnel do not utilize work rest cycles.

FUTURE EFFORTS

Competitive Contract. The current contract, from 1982 through 1987, is sole source. This contract was never structured to provide a production capability. When the Competition in Contracting Act was enacted in the United States, that required this program to be competed for production. Current plans are to award a competitive contract for full scale development with production options. Due to the effects of competition, the final configuration of the IMP suit may vary from the current contractor's design. Additional options will be placed on contract. For example: design changes that may be necessary to use night vision goggles or for more comfortable wear of the suit when under threat of chemical attack, (MOPP II). At the present, some personnel have worn the IMP in a MOPP II configuration by opening the zipper, removing their arms from the sleeves, and pushing the hood back of their head. They are still in the suit except for their arms and head, but are ready to obtain eye/respiratory protection very quickly. For MOPP II, the wearer does not need to be fully enclosed in the IMP suit.

Schedule. The Request for Proposal (RFP) for the competitive effort should be prepared by second qusrter, fiscal year (FY) 88. Award of the full scale development/production options contract is planned for fourth quarter, FY 88. Full scale development should be completed by FY 90, followed by the production decision. An effort will be made to shorten this schedule, if possible.

SUMMARY

The IMP suit meets the primary requirements of the Explosive Ordnance Disposal (EOD) mission. Comparison with the M3 suit shows that the IMP suit is superior to the M3 which it will replace. Much longer performance times will be possible with the IMP design. The IMP suit will be used worldwide for EOD support of airbase operability. This mission is primarily wartime, with training for wartime. However, chemical hazards can also occur during peacetime; EOD will be able to wear the IMP suit for a wide range of peacetime chemical uses.

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3. Contract F33657-82-C-0435, CDRL Number 1038-03-A, Minutes: Preliminary Design Review, February 1987.

4. Contract F33657-82-C-0435, CDRL Number 1038-05, Minutes: Critical Design Review, May 1987, attachment pages 93 and 94.

5. Technical Report, AD-TR-85-7, A Performance Evaluation Using the Impermeable Chemical Defense Protective Ensemble and the Standard Chemical Defense Ensembles, February 1985, page 62.

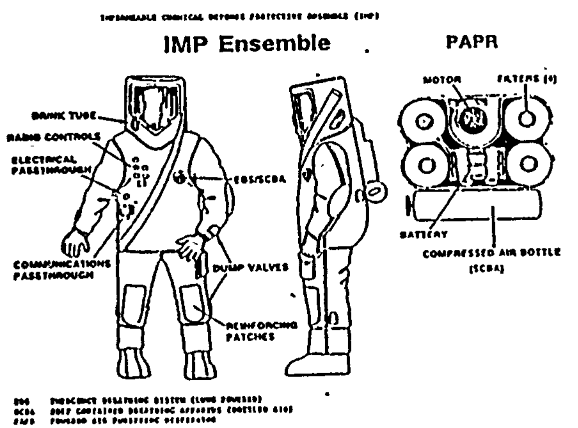

Figure 1 - IMP Suit (Improved design, 1987)

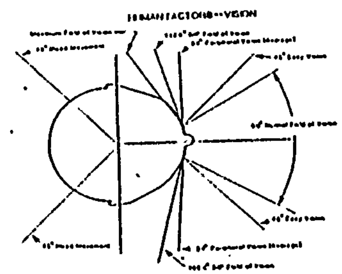

Figure 3 - Wide Field of Vision (side to side)

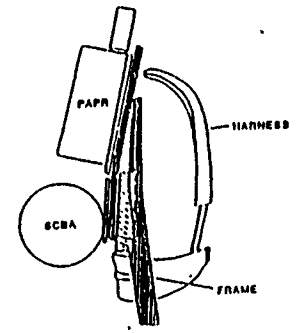

Figure 5 - Backpack Frame and Harness

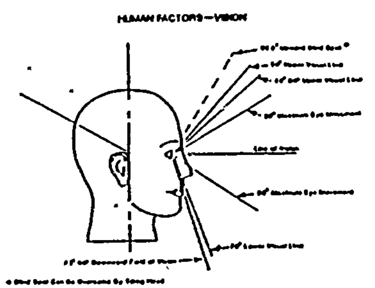

Figure 2 - Wide Field of Vision (upward and downward)

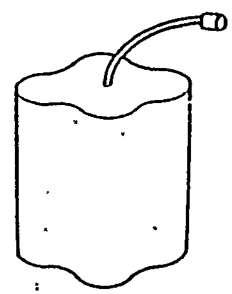

Figure 4 - BCX Lithium Battery

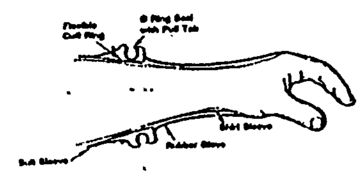

Figure 6 - Flexible Cuff

The Tactical Life Support System (TLSS)

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"Incoming!" That's the verbal warning that conventional weapons are being used against our forces. ("Silent pause") That is the sound of the warning the we may get from the use of chemical/biological (CB) weapons: the deadly silent of surprise. The concept of combined conventional and CB weapons is a very high probability. If we, as a free nation, are to be able to counter any type warfare, be it nuclear or conventional, we must be able to fly, and fight and win; anywhere and anytime, that's the Air Force mission. Today's discussion is one in a series of two very high-interest topics to the U.S. Air Force -- chemical warfare defense and high-G protection.

Traditionally, life support equipment has been developed piecemeal and is, thus, not well-suited to meet operational mission requirements for either training or combat. To address this and expand operational capabilities, a program was established in 1983 to develop an integrated system call the Tactical Life Support System, or TLSS for short. Weapons and aircraft technologies making mission scenarios more intense and demanding. Over the past several years the life support community has developed a good data base to better understand the physiology of flight, especially in the higher altitude and higher G regimes. This data has been used to formulate solutions to operational problems. I'll outline the operational objectives for TLSS as established by an underlying foundations of MAJCOM requirements. These objectives have leveraged technology to provide the user's a menu to choose from for specific applications. The bottom line is: High G protection has a near-term solution, and oh, by the way, protection under chemical and laser threats while expanding the flight envelope, is also provided.

I will describe the program in terms of the physiology involved and program objectives, followed by a short system description. I'll then review the recent flight tests results and tell you where I believe the technology is going.

With the advent of new technology engines and the necessity to travel longer legs, operations into higher altitudes are ultimately advantageous. The TLSS breathing system currently provides the aircrew protection for flight operations to at least 60,000 ft. The 9G requirement is certainly well understood. In a moment we'll discuss how these two objectives are tied together. The chemical protection by the head-mounted system and garments, and provides the same altitude and G capabilities as the standard TLSS system. To reduce anticipated heat stress under some conditions, an optional sub-system to provide body cooling is provided. However, TLSS can function without it. A single integrated garment (i.e., flight suit) ties all these functions together to provide routine don/doff capability.

Eye protection is provided by optional components for nuclear flash or multi-wavelength laser protection. To reduce logistics burdens of LOX, TLSS is compatible with, but not dependent upon, an on-board oxygen system. So that you will fully appreciate the intricate workings of the system, as opposed to piece-mealed components, I'll now briefly review the equipment sub-system.

The TLSS breathing system is made up of three components. First is the On Board Oxygen Generation System. It's a 3-bed molecular sieve oxygen concentrator that takes engine bleed air and basically separates the oxygen from the nitrogen, and produces breathing gas at the proper oxygen concentrations for specific altitudes. Such a system eliminates the logistics headaches of a LOX system. Should the aircrew desire 100% oxygen, the system contains a stand-by sub-system. He can make this selection with his oxygen control panel. The system contains a regulator which provides the aircrew with the proper breathing gas pressure for both altitude and acceleration protection. To eliminate clutter of many separate connections, a single-point release Personal Equipment Connector for breathing gas, G-suit air, and communications is mounted on the seat.

The TLSS anti-G system consists of a digital/programmable anti-G valve. A design objective was to have the G-suit inflate in under two seconds to provide protection in high G rapid onset rate situations. This valve has shown that it can inflate the G-suit in just over one second. This particular G-valve is pneumatically tied in with the breathing regulator to allow the regulator to provide the proper level of positive pressure breathing for G protection. Basically, PPB increases the pressure level of the breathing gas to the lungs. Equal mask pressure and a helmet bladder in the rear of the shell has the effect of making the high pressure <u>comfortable</u> while increasing the <u>internal</u> chest pressure with the breathing gas, TLSS provides <u>external</u> chest counter pressure to ease breathing effort, and <u>automatically aid</u> the pilot in his anti-G straining maneuver. Corresponding G-suit inflation helps to prevent blood pooling. This has the total combined effect of providing more blood and oxygen to the eye and brain. the result is less fatigue and increased endurance, without notice of the automatic PPB system.

The TLSS man-mounted equipment consists of the TLSS garmentry and head mounted systems. The garment is two-pieced for sizing considerations and is made of charcoal impregnated NOMEX fabric for CD applications. It also comes in standard NOMEX for normal operation. For G protection, the bladder coverage is increased by approximately 40% and built into the lower garment. Optionally, the TLSS cooling system provides conditioned or cooled liquid to a cooling vest to remove heat for those situation requiring it. The garment combines several functions into a single integrated garment "system". The helmet is a lightweight KEVLAR helmet. The mask tensioning bladder, again used with PPB, inflates as PPB is increased to provide a tight seal to eliminate leakage, and prevent slippage under high Gs. In the TLSS CB mode, a hose hooks up to the rear right of the helmet to provide ventilation/visor demist.

The TLSS mask has a new seal designed to hold the significantly higher mask pressures without leakage. Other unique features are the side entry hose, miniaturized microphone, and separate inhalation and exhalation valves. This mask is used in both TLSS standard and CD designs. The center of gravity of the head worn helmet and mask is virtually superimposed over the head's center of mass. Thus, the downward forces currently imposed on the aircrews when under high Gs are significantly reduced.

Laser protection is provided through the use of a laser visor that is directly interchangeable with the standard sunshade. It provides absorption protection against current enemy threats and friendly leaser. Finally, to provide nuclear flash protection, a PLZT goggle is incorporated into TLSS by mountings external to either the standard or CD visor.

During the past year extensive testing has been accomplished both by the prime contractor, Boeing Military Airplane Company, and by the Air Force. The contractor was tasked and did accomplish both component and system testing for performance under environmental conditions as identified by the usual military (MIL) standards, one of which was windblast testing. Again this was done at both the component and system levels. Once completed the next higher up level of testing was accomplished with emphasis on integration. Once the government was satisfied that all systems met or exceeded specifications, the government initiated man rating. Components and then higher level systems underwent a rigid scheme of evaluations both manned and unmanned. In the altitude chamber we evaluated the system for both routine and emergency situations for altitudes up to and including 60,000 feet. Included in this evaluation were slow and rapid decompressions under both manned and unmanned conditions. Subsequent testing on the centrifuge was accomplished. Both slow and rapid rates of G onset were used to subject the equipment to various conditions. Once satisfied that the equipment worked with unmanned runs, qualified centrifuge subjects were used to further evaluate the system. Eventually the subjects underwent the same G profiles that the TAC aircrews are currently experiencing. The results were of such a favorable nature that we decided to push the system's capability to see what kind of improvement in sustained G capability could be obtained. From what was seen in the centrifuge, we are currently to the point where a subject, to include aircrews, using the TLSS system can sustain 9 Gs for one minute with no light loss, tunnel vision, or other symptoms of G induced loss of consciousness. We finally did a cockpit integration evaluation to identify problem areas and compare TLSS with current aircrew equipment. After compiling results from the above evaluations, the School of Aerospace Medicine determined that TLSS met all specifications and was safe for flight testing in the F-15 and F-16 DT&E profiles.

The flight objectives were designed to assess capabilities and shake out the system. We wanted to identify benefits and weaknesses prior to full-scale engineering development and IOT&E. The system was flight tested by the Air Force Flight Test Center at Edwards AFB in the front cockpit of a F-15B. The Class II Mod was specifically designed for the purpose of collecting test data telemetry and ease of maintenance removal, should removal become necessary. It was not optimized as a Class V Mode would be. First flight was on 4 Dec 86. Prior to the flight, three primary pilots received several days of specialized training to include altitude chamber, centrifuge runs emergency procedures. The flight test program was organized into two segments totaling 30 sorties. The first segment consisted of eight familiarization sorties that provided an opportunity for pilot checkout and engineering tests. These flights used real time telementry to monitor system functions under specified conditions of airspeed, altitude and acceleration. After initial bugs were eliminated with the test instrumentation package, the system performed reliably and well. Pilot acceptance of positive pressure breathing under G conditions was both immediate and spirited. Comments at initual debriefs included, "9Gs feels like 5 to 7", and "No light loss, even at 9.5Gs."

System performance exceeded expectations and pilot acceptance was enthusiastic, thus allowing it to advance to the next series of missions. At this time we conducted one sortie that intentionally had a decompression to 28,000 feet to verify that the oxygen back-up system was functioning properly. subsequent tests were designed to assess TLSS in representative air-to-air and air-to-ground missions.

The pilots flew both mission types in three different modes-standard TLSS, chemical defense mode, and the laser visor configuration. TLSS performance in the air-to-ground mode served only to confirm its compatibility with the mission use of positive pressure breathing. In the air-to-air environment, we immediately saw verification of the increased endurance effects we previously observed in the centrifuge studies. On return from sorties that involved as many as ten ACM engagements with one or more tanker refuelings, the post flight debriefs included such comments as, "I am not consciously aware of straining at high G levels," I had no light loss even at 9 1/2 Gs," and "I now have no hesitation to go to high G, Fatigue is no longer a factor." The results were so positive that we thought it a good idea to have a TAC owned pilot fly several sorties. In coordination with the TAC staff, Maj Osterman from the 57th Fighter Weapons Wing at Nellis flew three sorties at Edwards. Some of his comments were, "I could whistle Dixie at 9Gs. It cut my workload in half", "I expect an increase sortie surge capability and I prefer to fly with it," and "The chem defense mode is light years ahead of the present system>"

While the F-15 flight experience was designed to test several new technologies, we also had a simultaneous package that was specifically designed to apply positive pressure breathing into F-16 aircraft. The F-16 SPO, in cooperation with the Life Support SPO and technical assistance from us, the TLSS office, flew 33 F-16 sorties. The nature of the findings of the F-15 TLSS flight experience along with initial findings of the F-16 suggests that positive pressure breathing is an equipment solution to a part of the GLOC problem.

During the flight test, the pilots adjusted flight scheduling so that the F-15 TLSS aircraft flew against the F-16 aircraft with its positive pressure breathing. Although the F-16 was solely looking at the positive pressure breathing, the F-15 flew against it using chemical defense mode and the laser visors. To remain as an honest broker and not judge who shot whom on which engagement, it is significant to emphasize that the aircrews began thinking and talking about changing combat tactics in order to capitalize on the improved total weapons systems capability and their enhanced advantages over potential advisaries. Near the end of the flight test program several of the aircrews informally expressed reservations about flying an air-to-air engagement against an opponent that had the TLSS or positive pressure breathing system unless they too were so equipped.

Some specific aircrew quotes made during mission debriefs are as indicated.

We have a short three minute video that I would like to present that will sum up this briefing so far. We now know that the system works. (In order to field this system or its derivative so that it will benefit tactical aircrews, I will discuss where this technology is going.) Our mission is to assist the F-16 and LSSPOs to package the system for specific F-15 and F-16 applications in order to rapidly effect the deployment in a compressed time period.

It is obvious that when compared to current life support equipment, the TLSS provides many improvements for the combat role. (i.e., 60,000 vs. 40,000 ft ceilings, PPB technology for G-protection, etc.)

Three major conclusions can be drawn to date even before the final test reports have been published. (1) Positive pressure breathing definitely increases fighting capability. (2) Technology now exists to permit operation to 60,000 feet and (3) for least for two of the fighters there exists a system that will operate in the chemical defense training and combat mode that represents a quantum improvement of the present system while providing PPB for G protection.

In summary, the flight test at Edwards have confirmed laboratory experiences. We, Brooks, and Wright-Patterson are taking a proactive approach to rapidly field the solution to the line aircrews. We've designed a system for rapid transit to FSED and are proceeding to execute it accordingly.

AIRCREW EYE/RESPIRATORY PROTECTION (AERP) PROGRAM

BY

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ABSTRACT

The purpose of the Aircrew Eye/Respiratory Protection (AERP) program is to provide all USAF aircrew chemical protection in a wartime environment. A first-generation aircrew chemical defense mask (MBU-13/P) was fielded in the late 1970s as an interim solution. The objective of the AERP program is to develop and procure improved eye/respiratory chemical defense protection to replace the MBU-13/P based systems. A four-phased approach is being taken to match hardware to aircraft, test the proposed systems, accomplish limited production for initial operational capability (IOC) aircraft, and then full production for the remainder of aircraft in the Air Force inventory. Initial concept demonstrations yielded seven primary candidate systems. Phase I, conducted Jun-Aug 1987, matches a system to each of the three IOC aircraft types. The paper will discuss laboratory testing and flight demonstrations used to verify/refute contractor analysis, the results of the Phase I analysis, the evolution of the AERP program from a USAF-only to a tri-service program, and the growth from seven tactical fighter aircraft to over 140 multicommand, multiservice aircraft.

OVERVIEW

In 1978, the USAF fielded the MBU-13/P Chemical/Biological Oxygen (CBO) Mask System, consisting of the MBU-13/P mask, CRU-80/P filter pack, and HGU-41/P protective hood. Concurrently, the USAF started development of an Integrated Chemical Defense System (ICDS) for Tactical Air Forces (TAF) application. In concert with this, the USAF explored a Chemical Defense Multipurpose Mask (CDM^2) concept for Strategic Air Command (SAC) and Military Airlift Command (MAC) in the early 1980's. In Nov 84, ICDS was cancelled due to technical and cost problems and, in Dec 84, the USAF restructured the ICDS and CDM^2 programs into the Aircrew Eye/Respiratory Protection (AERP) Program. AERP is a USAF tri-MAJCOM as well as a tri-service program. It is structured into several phases:

The first phase, completed in May 1986, was a 16 month study and analysis by Quest Corporation that concentrated on three main areas. First, aircraft were separated into nine categories based on weapon system similarity, threat scenario, and aircrew responsibilities. Secondly, MAJCOM specific absolute requirements were defined. Finally, Quest conducted a equipment/technology search to identify all existing (foreign and domestic) aircrew chemical protective systems. The end result was a recommended list of candidate systems for each of the nine categories that warranted further evaluation for possible fielding.

In conjunction with this, the USAF conducted limited testing and a comprehensive flight demonstration on several candidate AERP systems. This testing and demonstration (1) provided subjective feedback to verify the Quest analysis, (2) identified operational constraints, (3) provided insight to the type and complexity of aircraft modifications, and (4) identified design deficiencies that could be corrected prior to formal DT&E.

Based on the Quest analysis and flight demonstration results, seven AERP systems were selected (by the USAF) for consideration in the full scale development program. These systems are:

X-43
Advanced Chemical Defense Aircew Respirator (ACDAR)
Aircrew Respirator NBC No. 5 (AR-5) MK II
Aircrew Respirator NBC No. 5 (AR-5) MK III
High Performance Aircrew Mask (HIPAM)
Protective Integrated Hood/Mask (PIHM)
Tactical Aircrew Eye/Respiratory System (TAERS)

Phase II of the program was awarded on 8 Jul 87 to Boeing Military Airplane Company (BMAC). This contract is divided into four smaller phases. The first phase is a 60 day system selection analysis which will recommend an AERP system for each of the nine categories. The goal of this system selection is to minimize the number of AERP systems needed to meet all of the program requirements. Once the systems selections are made, the second phase of the contract begins. This consists of qualification testing, DT&E and IOT&E flight testing for ten USAF representative aircraft (Table 1). The third phase is the limited production of the AERP system(s) and aircraft modification kits for one wing of each of the ten USAF representative aircraft and two Navy aircraft (AV-8B and P-3C). Reprocurement data for the AERP system(s) is a deliverable in this phase. The fourth and final phase of the contract will provide the reprocurement data and one aircraft modification kit for all remaining aircraft (84 USAF, 55 Navy, 4 Army).

BACKGROUND

Phase I began with the Quest analysis. Quest Research Corporation surveyed all the users for their "absolute and desired" requirements. The users realized that all their requirements could not be met. Absolute requirements were based on requirements the users felt must be met to be operationally suitable and effective. An example of an absolute requirement is a protection factor of 10^4. An example of a desired requirement is a protection factor of 10^3 in the event of a blower failure. The users "absolutes" were turned into the AERP Technical Requirements Documents by AE engineering. Desired requirements would be incorporated into the prime item development specification.

Quest categorized all the different Air Force aircraft into nine categories. Later, when the Navy came aboard, the list was expanded. In each of the categories, a representative aircraft was chosen. The aircraft were put into these categories based on their mission and operational environment.

Quest surveyed the continental United States and NATO countries for existing chemical defense systems. Based on this survey, seven systems became part of the AERP Phase I laboratory testing and flight demonstrations. In addition to the systems previously mentioned, the Dutch In-Helmet System (DIHS) and the Advanced Israeli Hood/Blower System (AIHBS) were included.

TEST AND EVALUATION

The Laboratory evaluation started with USAFSAM/VNL performing man-rating tests required for the safety of flight for the flight demonstrations. The ACDAR, AR-5, TAERS, DIHS and AIHBS were man-rated. The M43 was not man-rated due to its extensive testing by the US Army. The PIHM and HIPAM were not evaluated during this phase due to their unavailability.

The man-rating tests consisted of breathing tests, cockpit integration tests and optics testing. The AERP systems were configured as non-complex as possible in order to facilitate man-rating. Three deficiencies were found with the ACDAR. The optics were distorted due to the curved shaped lens and the manifold could not be seen by the pilot. USAFSAM/VNL stated that the manifold being left in emergency could cause the aircrew member to become hypoxic. The aircrew member could not see to tell if the manifold was in emergency or normal. The third deficiency found with ACDAR was the filter control manifold (FCM) disconnect which caused high breathing resistance after ground egress. Scott Aviation had increased the FCM breathing supply quick disconnect tension to prevent water from entering the oronasal mask through the inhalation valve. However, the

USAFSAM evaluations indicated that using the standard spring tension of the CRU-60/P would prevent water from entering the mask. Therefore for the flight demonstration, Scott Aviation reset the tension of the FCM inlet quick disconnect to that of the standard USAF CRU-60/P.[3]

The AERP systems configured for the flight[1] demonstrations were windblast tested to verify structural integrity, and ACES II compatibility using a F-16 ACES II seat. All the AERP systems passed structural integrity tests to 450 KEAS. The two hose systems and the over-the-helmet systems failed to meet the following criteria: "ACES II aerodynamic compatibility shall be defined as both pitots measuring sufficient airflow pressure to cause at least 8 milliseconds sustained environmental sensor switching. Switching shall occur within the initial 37 milliseconds of the windblast, beginning at the peak airstream velocity generated by the windblast nozzle. The target peak airflow velocity over the test seat/mannequin shall be 350 $\pm$ 25 KEAS at sea level". Most systems marginally passed ACES II compatibility. Marginally is defined as only one pitot tube switching to mode 2. TAERS was the only system that successfully passed the initial testing. PIHM and HIPAM were also successfully tested. Later the TAERS, ACDAR and AR-5 MK III were windblasted for ACES II compatibility with LPU-9/P Life Preserver and Sea Water Activated Release System (SEAWARS). The TAERS and ACDAR passed. The AR-5 MK III was again unsuccessful.

AR-5 MK III, the DIHS, TAERS, ACDAR, and AIHBS underwent egress testing at Eglin. The egress testing consisted of water drag, ground egress and parachuting. No serious egress problems were noted except that the AR-5 MK III disconnected at up to a measured force significantly over the standard USAF disconnect force of 12-20 lbs. Therefore, for the flight demonstration, the AR-5 MK III was modified with a standard USAF connector instead of the connector supplied with the AR-5.[3]

After all the testing, the systems were given a safe to fly by the Life Support SPO. The systems were flown into various AF aircraft. All the systems were satisfactorily flown in fighter aircraft. The Air Force had a problem integrating the M43, and the HGU-55/P with the Thermal Plastic Liner (TPL). After successful fitting was accomplished using modified helmet fitting procedures, several helicopter sorties were flown with no reported comfort problems.[4]

The pilots flew the TAERS in a F-4, F-111, F-15, and F-16 using 100% oxygen. Because the 100% oxygen regulator has a lower inhalation resistance than the CRU-73/A but a higher exhalation resistance, pilots were requested to use the modified CRU-79/P oxygen regulator by breathing on the ground for a minimum of one hour prior to flights. The pilots flew the missions with no reported problems. There was an adequate supply of oxygen left in the liquid oxygen converter after the pilots flew representative fighter missions.

To ensure that the AERP systems provided a protection factor of 10^4, a protection factor test was performed at the Chemical Research Development and Engineering Center (CRDEC). The TAERS use of a low flow to provide over pressure and the ACDAR use of a charcoal hood were areas where the protection factor needed to be verified. The TAERS were initially provided with the charcoal hoods. ILC Dover conducted an in house protection factor testing using corn oil and found that the charcoal hoods permitted the aerosol to penetrate the TAERS. Therefore, prior to the tests, the charcoal panels were replaced with impermeable butyl cloth.[5] The ACDAR, M-43, and TAERS were tested for quality assurance prior to protection factor testing. The tests showed that the systems leaked. The USAF decided to continue the tests by using silicone to plug up the leaks. Once the leaks were plugged, the systems were able to obtain a protection factor of 10^4. To ensure that the production systems have a quality assurance procedure, a leakage test was added to the AERP TRD. The M-43 had no quality assurance problems and easily provided a protection factor of 10^4.

CONCLUSIONS

In conclusion, based on our study, analysis, flight demonstration, and limited testing, all of the candidates systems that the AERP program is evaluating for further consideration are under-the-helmet systems. For weapons systems with ejection seats, especially the ones with ACES II seats, the USAF needs an under-the-helmet system for ACES II compatibility and to use current on-helmet systems such as thermal flashblindness protective devices. For MAC and SAC missions that require electro-optical devices such as night vision goggles, an under-the-helmet system is required to provide the necessary eye coupling.

The USAF Phase I AERP program met its goals. The USAF surveyed all the systems that were available during the review. The USAF hopefully, identified most of the deficiencies with these systems through testing to let the integration contractor know that these systems needed to be modified before the Phase II contractor initiated DT&E qualification tests. Finally, the USAF updated their testing methodology from information obtained from the Army, Navy and our allies.

NL CHEMICAL DEFENCE GEAR FOR F16 PILOTS

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ABSTRACT

In 1979 NATO organised a conference with nearly the same title which opened the eyes of the RNLAF for the need of chemical protection of their pilots. A small study group was formed in which a pilot, a procurement officer, an NBC officer and an NBC researcher were appointed. In the first year the group studied the available solutions in the UK and US, they were both rejected as unacceptable for F16 pilots. In the second year it was tried to establish a cooperation with Germanny for a cooperative development and prototype developments in other countries were studied. This route was abandoned because the time frame in which these developments would become available did not correspond to the urgent needs of the RNLAF.
Therefore, the RNLAF started their own development, which resulted in an over the helmet system for head protection, an integrated chemical protective flight suit and impermeable gloves and overboots. The system was completed by plastic covers for transport over the airbase. The system was flight tested in the same year and although found acceptable for NF 5 pilots, it was not accepted for F16 pilots (too heavy).

Based on the first prototypes a second version was developed which actually is an in the helmet system. This system was flight tested by NF 5 and F16 pilots and was rated very good with no measuable degradation in performance. The comments of the pilots were that the head and body protection were comfortable to wear, the hand and foot protection needed improvement. In stead of overboots, the pilots were provided

with permeable NBC socks, and instead of impermeable gloves a new type of chemical protective flight glove was developed.
In first instance the system passed high speed wind tunnel and blast testing for the ACES 2 ejection seat. At the moment that the flight helmet was modified from HGU 26 P to HGU 55 P problems arose with passing the test. In the last three years modifications have been developed to obtain a system that will pass the blast test. This took relatively long because there is only a very limited capability to carry out those tests.
This summer final tests were run and the system has been accepted by the RNLAF.

In the presentation the system will be described and some of the test results will be discussed. An identical or very similar system is introduced or under consideration in Denmark, Norway, Belgium, and Israel.

1. INTRODUCTION

1.1 History

Work in The Netherlands on aircrew chemical defence (CD) started in 1979 by a small working group of RNLAF personnel; including a pilot and a member of the research community. The US and UK aircrew CD systems and those under development in the US and Germany (1) were not acceptable to the RNLAF. A cooperative development with Germany was soon abandoned because of the costs involved and the relative long development time. At the end of 1980 the working group decided to develop a system in The Netherlands.
In the course of 1981 a system comprising respiratory, eye and skin protection was proposed by PML-TNO (see Fig. 1). This system underwent laboratory tests in several ways and was finally tested in NF-5 aircraft by the RNLAF and in Saab Dragon aircraft by the Royal Danish Air Force (2). In both cases the system appeared to be acceptable. The complete system and part of the tests have been described in PML report 1981-26 (1).
During the flight trial doubt was thrown upon the acceptability of the system for F16 aircraft because of interference of the 'above-the-neck' protection with the Pitot tubes that sense the velocity of the aircraft during ejection (the velocity during ejection determines the mode in which the pilot is ejected). At that time two decisions were made:

- To develop a new above-the-neck system that will not cause interference with the Pitot tubes.

- To ask the 'National Aerospace Laboratories' to test several aircrew ensembles in their wind-tunnel for compatibility with the ACES II ejection seat.

At the beginning of 1982 a new system was available and this system was thoroughly tested on all aspects. In autumn 1982 flight trials started with NF-5 and F-16 aircraft. In early 1983 the system was approved for both aircraft.
During the flight tests the pilots commented on the overboot and the impermeable gloves which both interfered with the operational tasks. Therefore, NBC-socks instead of overboots and flight gloves which were permeable on one side were developed.
Before the system could be flown in a F-16 it had to be shown that there was no interference with the proper functioning of the Pitot tubes from the ejection seat. This was demonstrated in a high speed wind tunnel. The CD helmet did not react differently from the normal HGU 26 P helmet.
At the point in time that the system was up for acceptance two problems arose. Firstly, it was decided that the HGU 26 P was too heavy for F 16 pilots and the helmet had to be modified to a 55 P configuration. Secondly, a message came from the USAF that during blast testing of CD helmets interference with the Pitot tubes was found. The blast tests carried out subsequently with the NL CD helmet showed that indeed tall pilots could experience problems.
After a thorough discussion with US-experts on blast testing it appeared that the conditions used during the NL/BRD tests needed adjustment. In order to reduce those kinds of problems further, modifications of the existing system, especially around the neck, were developed. In June 1987 blast tests were run again and the system has been accepted by the RNLAF.

1.2 Previous reports and contents of present paper

The first Over-the-Helmet System is described in ref. (1). The second version, actually an In-the-Helmet-System, has been fully described in PML report 1984-4 (3). In this report also the NBC-flight coverall and the entry-exit procedure are described together with the tests

carried out to demonstrate the chemical integrity of the system. This report has been published also as a document of NATO AC 225/ (Panel VII) Air Sub Panel, Working Paper 44 (4).
In PML report 1985-10 (5) the half permeable aircrew gloves are described. Although the results of this development have been presented to the Air Sub Panel, the distribution of the report has been limited and the gloves will be described in somewhat more detail. Possible modifications/improvements of the In-the-Helmet System are described in PML report 1985-C-63, a study performed under contract with the USAF (6).
In the present paper the NL aircrew chemical defence system will be described briefly. For detailed information the reader is referred to the previously mentioned reports. The emphasis will be on the background of the whole development.

2. BACKGROUND OF THE DEVELOPMENT

2.1 General

In the study phase of aircrew chemical defence which started in 1979 and continued uptil now, the RNLAF and PML-TNO studied several aspects and learned a lot.
An important aspect of aircrew chemical defence is protection. The required protection should be based on the quotient of the maximum possible challenge dosage to aircrew and the maximum allowable exposure of aircrew.

$$\frac{\text{CHALLENGE DOSAGE}}{\text{ALLOWABLE DOSAGE}} = \text{PROTECTION FACTOR}$$

A second important aspect is comprised in the term COMPATIBILITY. The system should be compatible with:

- The aircraft
- The life support equipment of the pilot
- The ground procedures to be followed by the pilot
- The operational task of the pilot, no interference with task performance.

Requirements following from compatibility and protection factor can work in an opposite direction. For instance when the challenge dosage is chosen high, or the allowable dosage is low, then a high protection factor is needed. High protection factors can be achieved by enveloping the pilot by an impermeable barrier. The higher the protection factor needed the bigger is the barrier between the pilot and environment. Compatibility with aircraft and life support equipment becomes questionable in that case and certainly there will be a degradation in task performance. Generally speaking compatibility is inversely related to the protection factor. COMPATIBILITY = F(1/PROTECTION FACTOR). Because of this relation it is mandatory to analyse the required protection factor in greater detail and thus evaluate quantitatively the CW challenge to a pilot and the maximum allowable exposure. Typical Dutch requirements are that the system must be cheap, simple and made from 'of-the-shelf' articles, available either in The Netherlands or friendly countries. The system is composed of parts from Germany, Belgium, Japan, UK and US.

2.2 Chemical Challenge Levels to pilots

Chemical Challenge Levels to pilots on fixed air bases can be only arrived at using classified information. In this paper we will use imaginary figures for the discussion. Those data can be found in

Working Paper 51 of the Air Sub Panel (7) or in recent studies from the Special Project Office of USAF/HSD/HE (8).

Chemical Challenge is of two kinds, a vapour challenge and a liquid challenge. The liquid challenge can be caused by direct contamination or by secondary contamination from pick-up. Both vapour and liquid challenge can occur in three phases:

1. During flight
2. During ground operations outside the Briefing Facility
3. During entry/exit or stay in protected Briefing Facility.

Vapour challenge

The vapour challenge in phase 1 and 3 is mainly caused by evaporating liquid brought in by the pilots themselves or by other personnel. Sometimes the vapour sucked in through the Environmental Control System is mentioned as a source of vapour challenge in phase 1 during take off and landing. However, concentrations are reduced considerably by the ECS itself and the exposure times are very short, so the contribution to the total challenge dosage is small.

The challenge directly from vapour is mainly when the pilot is on the ground in the open. These times are relatively short in the order of 15 minutes to half an hour. In addition the agents that form a direct vapour hazard are evaporating relatively quickly. For instance 99 % of a liquid GB challenge will disappear in 15 minutes under summer conditions and 80 % of a liquid GD challenge has disappeared in 30 minutes. It can be demonstrated (9) that in first approximation the vapour exposure from liquid in enclosed ventilated areas is:

$$\text{Dosage Ct in mg.min/m}^3 = \frac{\text{amount of liquid present in mg}}{\text{ventilation rate in m}^3\text{/min.}}$$

This is an overestimation for slow evaporating liquids. If one assumes 100 mg of liquid to be present in a Briefing Facility with a ventilation rate of 10 m^3/min the total dosage to which the inhabitants are exposed is 10 mg.min/m^3 during a continuous stay. (The simple formula given above can help a lot in evaluating the challenge to pilots, the result is independent of temperature, kind of agent or volume of the enclosed space).
If for some reason the same amount of liquid is found in a cockpit with a ventilation rate of 0.3 m^3/min, then the total exposure would become Ct = 330 mg.min/m^3, again if the pilot stayed in the cockpit during the full evaporation time of the liquid.
Summing up the exposures to vapour one arrives at a certain value per chemical attack. Assuming a ten day war with two chemical attacks per day one could maximise the dosage by multiplying the dosage per attack with 20. However, the chances of a pilot being always in the most unfavourable conditions is very small, (the chances of being three times in the most unfavourable conditions is 1:8000).
For further evaluations of the PF we will use an exposure of pilots to a Ct = 5000 mg.min/m^3 (99 percentile) of which 3000 mg.min/m^3 is received in short exposures leading to cumulative incapacitating effects and 2000 mg.min/m^3 is received at low concentrations continuously over a period of ten days.

Liquid challenge

Assuming that the eyes, respiratory system and the skin of the head are always covered in such a way that they are impermeable to liquid agents the challenge of liquid is to the skin of the body. This assumption might be obvious but the requirement of impermeability of the above-the-neck protection is not always fulfilled in the present systems. In laboratory tests some of the materials in use showed penetration of dangerous quantities after 1-2 hours of after 24 hours in a simulated re-use of the equipment (10).

Relatively simple procedures can prevent the direct liquid contamination i.e. providing always a kind of overhead cover for the pilot e.g. transport by car from SPBF to TAB V. To prevent direct liquid contamination the pilots from the RNLAF are transported in disposable plastic capes and boots in case of CW (see Fig. 2).

The remaining liquid challenge is from indirect contamination by pick-up, e.g. a contaminated individual has serviced inside the cockpit or the pilot has picked-up contamination from the outside of the aircraft on entering. Although these contaminations will usually be small and can be prevented to a large extent by being careful they cannot be completely disregarded. A special problem is when the liquid is present on so-called pressure points, e.g. the seat. In that case liquid is pressed into the protective fabric and the generated vapour can only diffuse towards the skin. A similar situation could result during contamination of the flight gloves and the throttle or stick. The analysis of the challenge to air bases (7) has shown that only a fraction of the service personnel will be contaminated with drops of say 1 mg or more up to a level of 1 g/man or more.

The rule is that personnel contaminated to this level must go to a decon-station. In the unfortunate event that they are not able to obey this rule they might cause cross-contamination. The transfer of agent from a contaminated man to other men or the cockpit is never 100 % and the largest secondary contamination that might be expected is in the order of 100 mg of liquid total in drop size upto 10 mg. The skin of the body is covered by one or more layers that prevent the direct contact of liquid with the skin. The hazard results, however, from vapour that is generated by the liquid. The evaporation rate and the percutaneous toxicity of the nerve agents combined with the fact that they are systemic poisons make that the total expected liquid contamination is not very hazardous. The situation is very different for blister agents. They act locally on skin and the vapour generated by a drop of 1 mg or smaller deposited on several layers of textile is sufficient to make a

man a casualty. The emphasis of body skin protection must therefore be against the secondary contamination with blister agents.
The possibility that a pilot is contamined on bare skin during doffing and donning of contaminated equipment can not be ruled out. The quantities that are involved are again relatively small. Probably maximum contaminations in the order of 1 mg and blister agents are the main hazard.

2.3 Allowable dosage

What one is looking for are the dosages for varying exposure times that would not cause effects interfering with the operational tasks of a pilot. Those dosages are not available for humans. This lack of data is also mentioned as a great difficulty in determining required protection factors in Working Paper 52 of the Air Sub Panel of AC/225 (11). Generally the effects of nerve agents are cumulative upon successive exposures. Only in case of GB a very low detoxification rate is known from literature. On the basis of the detoxification rate McNamara et. al. (12) have derived a concentration of GB to which workers in a chemical ammunition disposal plant may be exposed continuously (0.005 mg/m^3). This value could be used as a safe concentration in cases where long exposure times and low concentrations are involved. Because of the cumulative effects of successive dosages of nerve agents it is not allowed to say that a Toxic Free Area in which the concentration stays below 0.005 mg/m^3 is safe (13). The human body is in that case still detoxifying absorbed agent from previous exposures to higher concentrations over short periods. So only in the case that the exposures outside the TFA are always below 0.005 mg/m^3 the Ct dosage can be expressed as $(C-a) \times t$, in which a is the detoxification rate.
For short exposure times, upto half an hour, ref. 11 gives an eye and respiratory incapacitating dosage. For demonstration purposes we will adopt a value of ICt 5 = 5 $mg.min/m^3$. (The imaginary dosage for which 5 % of the pilots would become incapacitated).

Consequently for aircrew eye and respiratory protection two toxicity criteria could be used. The most safe criterion is:

- The concentration of nerve agent vapour to which aircrew is exposed should always be below 0.005 mg/m^3.
- For one short term exposure (upto half an hour) it would be acceptable to restrict the exposure to a Ct = 5 mg.min/m^3.
  (This is the value adopted in this paper, the actual value to be used should be derived from ref. 11).

The challenge from vapour to the skin is only one or two orders of magnitude higher then the incapacitating dosage and relatively small protection factors can be regarded sufficient. The vapour hazard to the skin resulting from the local liquid challenge of blister agents is a more serious problem. Penetrations as low as 4 µg/cm^2 on sensitive body areas can be incapacitating. For instance if a 10.000 µg drop is present on the seat it must be reduced by adsorption in the protective fabric to less than 4 µg.

2.4 Protection factor

Important message

Using the total exposure value of Ct = 5000 mg.min/m^3 in a ten day war the exposure of pilots in a surprise attack (no warning, no protection) can be upto several hundreds of Ct. This is two orders of magnitude larger then the allowable dosage. Therefore it would be wise to develop a protective system that can be flown all the time, sacrifying some of the protection factor against compatibility.
In the paragraph on challenge the total vapour dosage during a ten day war was given as Ct = 5000 mg.min/m^3 from which 3000 is received as short exposures and the remaining 2000 at a low concentration during 14000 minutes. In the short term exposures the maximum concentration that can be encountered by a pilot is 150 mg/m^3. Using the

two criteria for the allowable dosage one can arrive at various protection factors for the eye and respiratory system:

- With a total challenge of 5000 mg.min/m³ and an allowable dosage of 5 mg.min/m³ a continuous protection factor of 1000 is required.
- Using the criterion of the allowable concentration 0.005 mg/m³ and the maximum concentration that can be encountered by a pilot (150 mg/m³) a protection factor of 30.000 is required. However, this high value is necessary only in the periods of high concentrations. During the majority of the time a protection factor of 100 would be more than sufficient to protect the pilots. (2000 Ct in 14000 minutes gives an average concentration of 0.15 mg/m³).

The criterion of an allowable concentration of 0.005 mg/m³ holds for the agent GB, for GD and VX it is unknown but probably lower, but the maximum concentrations of GD and VX that can be experienced by a pilot are lower because of the lower vapour pressure as a result the required protection factor is of the same order.
From respiratory protection studies it is known that a protection factor of 100-1000 can be achieved by a normal service respirator. Critical points are face seal leakage, leakages through outlet valves and leakages through filters. The military requirements for a filter are leakages in the order of 3.10E-5. So by using normal military filter canisters and reducing the leakages through the face seal and the outlet valves a protection factor of 30.000 might be achieved. The reduction in leakages is normally achieved by creating an overpressure inside the mask using a powered air supply. An alternative approach is providing clean air around face seal and outlet valve. This latter approach is followed in the NL system.
The air supplied to the oxygen mask is filtered through the CRU 60 P filterpack and clean air is provided from a filter blower unit to the eye area and around the oxygen mask. The filter pack is mounted on the parachute harness, the filter-blower unit is carried by hand or

mounted in the aircraft. In this way the weight increase on the pilots head is minimal and what is felt as a comfortable stream of air is provided over the face.

Regarding the protection required for the body skin it became apparent that the main hazard is from blister agents in sensitive body areas and from accidental cross contaminations during donning and doffing. An overall protection factor of 2500 is therefore required and special precautions should be taken during donning and doffing. Most NBC protective materials in use in NATO armies provide this protection factor, however, for a limited period of one or two hours only. If those materials are used, their use is restricted to one sortie. The RNLAF required an integrated chemical defence flight suit that could be used during at least ten sorties. Therefore the high quality saratoga materials were chosen. In a single layer they still could not meet the stringent requirement of the RNLAF and chemical protective underwear was added. The concept of a NBC protective undercoverall also provides protection during donning and doffing.

2.5 Capacity of protection

For most NBC protective systems the protection factor as mentioned in the previous paragraph is not provided for an infinite time or an infinite large challenge. Mostly the operational required capacity is based on the challenge met by an infantry soldier, e.g. the filter canister must be able to protect against one blood agent attack and against a series of nerve agent attacks. The protective clothing must provide protection for at least six hours. It is clear that the challenge to the eye and respiratory system met by pilots on a fixed air base is of a different order. The capacity provided in normal military filter canisters is more than sufficient to last the depicted ten day war, with 20 chemical attacks.

The analysis of the vapour challenge shows that replacement of filters is not required. An exception to this rule should be made for pilots

experiencing a blood agent attack in the forward area after ejection. A full analysis of the chemical challenge to the body skin has not been made yet. Protective fabrics are available that can stand 5 repeated 1.25 mg H contaminations on the same spot. The same fabric, however, will provide just six hours protection against a 10 mg H drop. It is expected that combining two layers with the same capacity would provide a body skin protection for many sorties.
For the protection of the hands such a system would become too thick and one time use NBC protective gloves have to be used.

3. DESCRIPTION OF THE EQUIPMENT

3.1 General

It has become customary to divide chemical protection of aircrew in three parts:

- Protection 'above-the-neck' mainly for the eyes and respirator system
- Protection 'below-the-neck' for protection of the skin against agents in liquid and vapour form
- Entry/exit procedures.

In addition to the special clothing and equipment for C-protection the pilot will use his ordinary gear. The complete outfit of the NL pilot will be described in this chapter.
During his stay in the briefing room the pilot is wearing parts of the total system. On the one hand this is done in order to be prepared for a rapid exit, on the other hand to provide protection in case the collective protection shows a failure. In the contamination control area, where dressing and undressing takes place, clothing and equipment is donned to provide full C-protection. Just before the exit of the CCA the additional flying equipment is added and measures are taken

to prevent heavy contamination. Then the pilot is transported by car to his aircraft. Some precautions are taken to prevent contamination transfer into the cockpit. The RNLAF is still working on proper procedures for turn around of aircrafts under chemical warfare conditions. This part will not be described.

In the following paragraphs the outfit is divided into three groups:

1. Clothing and equipment worn inside the PBF
2. Clothing and equipment especially developed to provide chemical protection; this is donned and doffed in the dressing/undressing area
3. The equipment on top of a flying overall, normally used by a high performance aircraft pilot.

   The main arguments for the actual design and construction of the various parts have already been given in report 1981-26 (1).

   For every piece of equipment we will indicate whether it is standard or especially developed and also whether it is meant for re-use after a sortie or whether it is disposable.

3.2 Clothing and equipment worn inside the PBF

3.2.1 Short underpants, cotton, knitted fabric, standard, re-usable

3.2.2 Flying socks, wool, knitted fabric, standard, re-usable

3.2.3 NBC-protective under-coverall of a design shown in Figure 3.

The under-coverall is composed of, from inside to outside, knitted cotton fabric, dots of charcoal spheres, knitted flame retardant cotton fabric. Elastic bands are fitted on the sleeves and the legs in order to hold the under-coverall in proper position during dressing and undressing. The elastic bands fit around the thumbs and feet respectively. The under-coverall is disposable and has been developed by Blücher GmbH.

3.2.4 Chemical protective charcoal loaded foam socks are worn on top of standard flying socks. (Especially developed by Seyntex and Blücher GmbH.) The foam socks are disposable. The socks can be made of the same material as the under-coverall. In that case they can be integrated into the under-coverall (Figure 3).

3.2.5 Cotton gloves, standard, disposable. These gloves are not worn but are directly available from one of the pockets in the under-coverall (Figure 3).

3.2.6 Chemical protective half permeable flight gloves, disposable. Also directly available from one of the pockets in the under-coverall. During the study several types of impermeable, semi-permeable and permeable gloves have been considered. The half permeable flight gloves (Figure 4) are preferred.

3.2.7 Carried on the man in the briefing room, a haversack with respirator and atropine injector for emergency situations, standard. The respirator is re-usable. If the standard Canadian C-3 respirator is used the pilot's head will not be protected against liquid contamination. Therefore, it is proposed to provide the pilots with US M-17 respirators including a hood.

3.2.8 Standard disposable plastic gloves and plastic bags (feet protection) are available at the exit of the briefing facility.

3.3 Clothing and equipment donned and doffed in the dressing area

In addition to the articles worn inside the PBF the pilot is provided with:

3.3.1 An integrated chemically protective flame retardant flying overall. The design of the overall is shown in Figure 5. The overall is especially developed by Blücher GmbH (Dusseldorf, Germany) and is re-usable. The overall, is from inside to outside, composed of the following materials: flame retardant cotton-layer of charcoal spheres fixed onto the cotton, mineral fibre laminated onto flame retardant cotton, treated oil repellent. The collar of the overall is of a special design in order to get good C-protection around the neck, without restriction of the manoeuvrability of the pilot's head. In all places where zippers or velcro is used there is an overlap of active carbon-loaded material.

3.3.2 Modified HGU 26P helmet; details of the modification are shown in Figure 4 An air inlet on the back-side provides air through a channel in the custom fit lining to the area above the eyes via 10-12 nozzles. The modification is carried out by the life support groups of the RNLAF. The helmet is re-usable.

3.3.3 Oxygen mask, 5P standard, re-usable after cleaning. The oxygen mask can be provided with a valsalva unit.

3.3.4 Filter-pack, CRU 80P. The filter-pack is also used in the USA interim solution. It is produced by Sierra (California, USA). The filter-pack is re-usable during more than 10 sorties.

3.3.5 Communication unit on the ground, designed by the electronics work-shop of PML-TNO.

3.3.6 Neck cover, made out of Hylla-material (flame retardant cotton-mineral fibre) combined with a layer of polyvinyl fluoride to provide C-protection. It is disposable, the material is produced by Blücher GmbH, the covers are made up by the life supports group of the RNLAF.

3.3.7 Visor; a modified visor and housing of the HGU 55P helmet. The modifications are shown in Figure 6.

3.3.8 A filter-blower unit. The unit consists of a battery pack of re-chargeable Ni-Cd batteries, a blower motor and a ventilator, all parts of a standard blower unit used in mining and produced by MSA (USA). The housing is modified in order to fit a respirator canister with NATO standard screw thread before the air inlet. Mounting is provided to mount the blower unit inside the cockpit of the NF-5 aircraft. For F-16 aircrafts the same elements are used in a different configuration.

3.3.9 The hoses from filter-pack to oxygen mask and from the blower unit to the helmet are covered with hylla-polyvinyl fluoride in order to make the hoses chemically resistant and to provide better flame protection.

3.3.10 To facilitate dressing and undressing procedures the pilots use in the CCA a trolley. The filter-pack, blower unit and communication can be hooked onto the trolley.

3.4 <u>Equipment on top of flying overall</u>

3.4.1 Leather flying boots, standard, re-usable. The laces have been devided into two parts in order to facilitate dressing and undressing.

3.4.2 Life preserver, standard, sometimes combined with parachute harness.

3.4.3 Parachute and parachute harness. NF-5 pilots will wear the complete EFA parachute. F-16 pilots only wear the torso harness.

3.4.4 The filter-pack is mounted on the same CRU 60P connector as the normal connector to the oxygen mask.

3.4.5 A quick disconnect is mounted in the hoses from the blower unit to the helmet. For F-16 pilots the quick disconnect is mounted on the right hand side on the parachute harness, through a standard clip-in fitting. For NF-5 pilots it is mounted on the lower left hand side on the parachute harness.

3.4.6 Anti-G-suit, standard, re-usable.

3.4.7 Communication unit hooked onto Anti-G-suit.

3.4.8 Flying gloves, NBC protective half permeable (see Figure 4) disposable.

3.4.9 Three colour liquid detection paper, fixed onto areas that are likely to become contaminated, disposable.

3.4.10 Long plastic boots, disposable, produced by Helly Hansen, Norway.

3.4.11 Plastic cape, disposable, produced by Helly Hansen, Norway. An example of cape and boots is shown in Figure 2. These articles are meant for additional protection during transport from and to the aircraft.

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Fig. 1. First NL Over-the-Helmet CD system

Fig. 2. Pilot ready for transport in disposable plastic cape and boots

Fig. 3. NBC protective under-coverall and NBC-socks

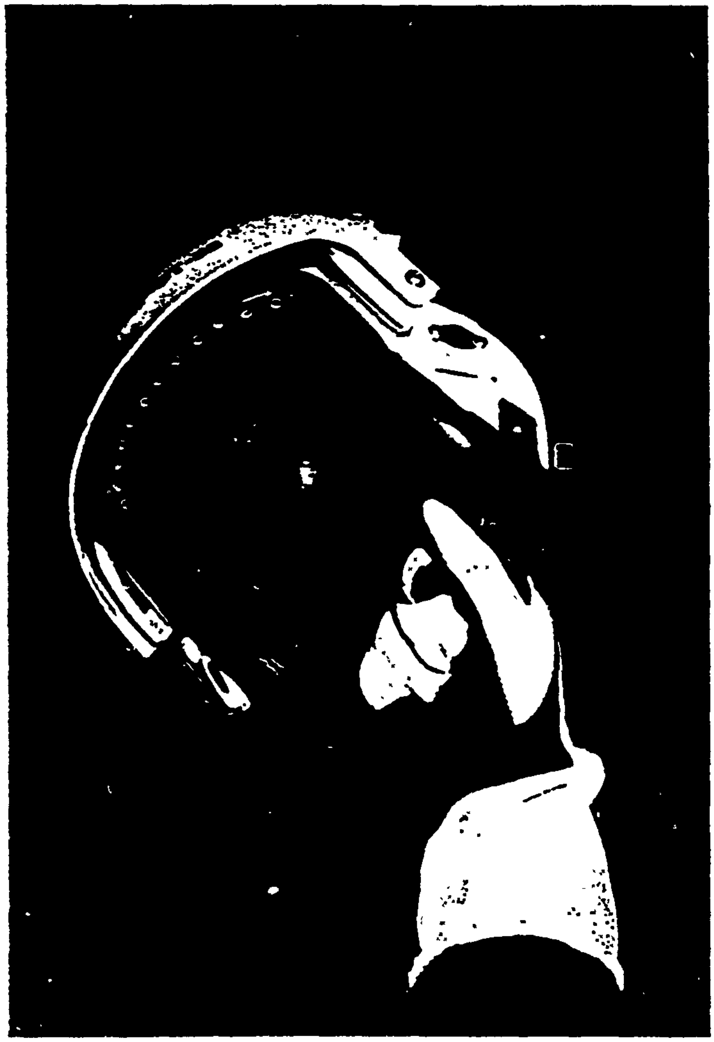

Fig. 4. NBC protective half permeable flight gloves

Fig. 5. Integrated NBC protective flight suit

Fig. 6. Pilot with + above-the-neck-protection

Fig. 7. Filter blower unit mounted in F16

MAINTENANCE OF AIRBASE OPERATIONS
IN A
CHEMICAL WARFARE ENVIRONMENT
SYMPOSIUM

CHEMICAL PROTECTIVE CLOTHING SYSTEMS FOR AIRCREW APPLICATIONS

ABSTRACT

The US Air Force since 1981 has pursued the development of a fabric system unique to the requirements of aircrews exposed to the threat of chemical warfare agents. The ultimate goal of the USAF fabric development program is to field a new aircrew coverall system which provides protection from a vapor chemical agent threat in addition to retaining the necessary flame protection, suit configuration, and fabric physical properties as required by the standard, non chemical defense flight suit coverall. The current operational concept employs the use of the British Mark I undercoverall which is nonlauderable, has a relatively low air permeability and must be worn with the standard flightsuit and nonthermal long underwear. This new chemical defense ensemble will essentially combine those three pieces of equipment into a single layer system. The fabric system is designed to be launderable and still provide chemical protection. It is a woven fabric with a higher air permeability which in combination with the reduced number of layers provides improved comfort. The fabric system is also designed to provide durability sufficient to employ the ensemble for training use for an extended period of time.

Mr. Louis Sweitermann

CHEMICAL PROTECTIVE CLOTHING SYSTEMS FOR AIRCREW APPLICATIONS

The aircrew member engaged in a chemical warfare environment is faced with some unique problems and limitations which will handicap the individual at a time when he needs the least amount of hindrance possible. The poisoning by chemical agents is an obvious hazard but equally hazardous can be the debilitating effects of and the emcumbering aspects of wearing the chemical protective equipment. So much so the enemy can actually diminish the effectiveness of a fighting force simply by posing the threat of chemical warfare.

Therefore the System Program Office at Wright Patterson AFB initiated the chemical defense equipment development program to improve the operational capabilities of our personnel involved in a chemical warfare environment.

The objective of our development effort entitled the Chemical Defense Aircrew Ensemble is to initially develop or modify a unique fiber and fabric system to provide the necessary chemical and flame protection.. Additionally the objective is to improve on current fielded equipments limitations, such as heat stress and non reuseability. Once the fabric material has been established it is then cut and sewn into garments designed for the specific mission of the aircrew member.

BACKGROUND

The Air force became aware of the potential threat from chemical warfare as a result of the HAVE PLOT study1.. The first generation equipment was procured with minimal development effort and was an effort to put equipment into the field as soon as possible. Therefore the first generation equipment was predominantly off the shelf equipment and in the case of the British mark I undercoverall was purchased on a sole source basis. The second generation equipment is the thrust of the ensemble development effort initiated by the program office in 1981 with the award of development contracts to two companies Gentex Inc. and Rohm & Haas Co. Concurrent with our own fabric development efforts, fabric research in the other services and by foreign governments has been monitored for possible applicability to the U.S. Air Force mission. One such concept based on the German fabric technology has been identified for its potential and is being included in upcoming wear trials. All competing fabrics in the wear trials will be cut and sewn into the same flight suit design.

DESCRIPTION OF CURRENT TECHNOLOGY

The current US Air Force doctrine employs the use of several layers of clothing to protect against the chemical threat.

They include the following;

A clear polyethylene disposable overcape used for transit to and from the cockpit, the purpose for the overcape is to prevent liquid contamination for a short duration of time.

The standard flightsuit coverall is retained during chemical warfare situations and its primary purpose is to provide flame protection for the aircrew member.

The chemical agent protection is provided by the use of the British mark I undercoverall. The mark I is composed of a nonwoven polyamide and viscose rayon material treated for oil repellency on the outside and with activated carbon powder coated on the inner surface. The mark I is a disposable item.

Completing the ensemble is the use of cotton nonthermal long underwear worn for two reasons one, to absorb perspiration and prevent saturation of the Mark I's carbon and two, to prevent skin irritation to the individual.

SYSTEM DEFICIENCIES OF CURRENT FIELDED EQUIPMENT

The limitations imposed by the present ensemble are the increased thermal burden, the low flame resistance of the undercoverall and the high cost of a disposable garment. The higher than desirable thermal burden is principally due to the multiple layers of garments that have to be worn which in turn reduce the air permeability of the ensemble and the increase the insulative effects due to the trapped air layers. Additionally the ensemble is bulky and cumbersome restricting movement and requiring additional time to don and doff. Because it is disposable it adds to the logistics burden and increases the cost per man-year for use of the garment.

DESIGN REQUIREMENTS FOR THE NEW ENSEMBLE SYSTEM

With the deficiencies of the current system in mind the requirements of the new ensemble system can be outlined. The fundamental change we are making in going from a first to a second generation ensemble is to combine the attributes of the multiple components into a single layer fabric system, plus adding the capability to be laundered. The reason for a single layer composite is that it is the best way we know of with present technology to significantly reduce thermal stress.

This is no easy task considering the contradictory nature of the requirements for the materials. The fabric material must be optimized to absorb chemical agents it does not directly follow that the fabric will be nonflammable and furthermore the fabric will probably not be very durable. Reducing the weight and increasing the air permeability of a fabric will improve its comfort but at the same time will reduce its resistance to penetration from liquid contamination. Complicating the material development further is the requirement that the fabric material must provide chemical agent protection after being exposed to sweat, oil and dirt contamination. It should also possess or be treated to possess nonstatic producing properties. The new fabric if it is to be sewn into a stand alone garment must be launderable and durable enough to make it cost effective. These requirements can be achieved. Our study of some of the fabrics indicate that these requirements can be met to a large extent. However some trade-offs are required.

SURVEY OF CANDIDATE TECHNOLOGIES SYSTEMS

The current technologies under consideration by this program are all permeable woven fabric systems and they can be separated into three distinct categories. The laminated fabric concept is the most near term technology and it is based simply by taking the multiple layers reducing their weight and then laminating them into a single layer composite. The Intimate blend concept takes this one step further by creating a homogeneous fabric composed of flame resistant fibers and chemical absorptive fibers held together mechanically. The ultimate woven fabric concept is to incorporate reactive and absorptive resins into the fiber itself and then weave fabric from the specially preformed fiber.

LAMINATED FABRIC APPROACH

The laminated fabric concept under consideration is referred to as laminated Saratoga, Hylla Saratoga developed for the German ministry of defense is the forerunner of the version which we are evaluating for aircrews called Monopak Saratoga. The Monopak Saratoga uses the same activated carbon spheres as used in the German development of Hylla Saratoga. However the sphere weight and loading has been reduced from 180 to 120 grams per square meter. The spherical carbon is laminated between an outer layer of flame resistant aramid fabric and an inner comfort liner. The weight of the finished cloth is approximately 400 grams per square meter. The critical aspect of this technology is the choice of adhesive used in the laminating and manufacturing process. The glue must be strong enough to withstand laundering and wear and at the same time not coat the carbon reducing it surface area and thus preventing the absorption of agents.

The advantages of this approach are that it has high retained absorptivity after laundering and appears to be resistant to sweat and moisture2. Also even though it is one of the heavier fabrics we have evaluated, it shows substantially reduced heat stress compared to the mark I.

INTIMATE BLEND FABRIC APPROACH

The intimate blend fabric concept a product of the Air Forces own development contract with Gentex Inc. is based on a yarn spinning process which combines high strength flame resistant fiber with a more brittle chemical agent absorptive fiber. The flame resistant fiber is the same as is used in the standard flightsuit coverall which is Nomex aramid fiber. The activated carbon fiber is derived from a Polyacrylonitrile (PAN) precursor and is mixed into the yarn bundle to approximately 25 percent by weight. The finished weight is 227 grams per square meter (6.7 Oz/Sq Yd). The advantages of this approach are its very light weight of the finished cloth and the ease with which it can be sewn. The fabric demonstrates a very low accumulation of static electricity due to the conductive nature of the activated carbon fiber distributed throughout the cloth. Also because the fibers are mechanically held together they should prove to be more durable and launderable3. The Gentex fabric along with the previous saratoga fabric are the two that will be tested in upcoming wear tests.

RESIN LOADED FIBER APPROACH

The third type of fabric system evaluated, also the product of an Air Force development contract is the Rohm and Haas resin loaded fiber approach In this design, cabonacious absorptive resin and strong acid reactive resin are loaded into a solution of polybenzimidazole (PBI) which is then extruded into a fiber. The substrate fiber PBI is highly flame resistant and provides sufficient strength to support fabric weaving. The advantages of this concept are its inherent flame resistance and good abrasion resistance.
However the fabric is not available in sufficient quantities to make garments and therefore will not be tested in upcoming wear trials. The overall technical shortfall of this approach is that the protective resins are encapsulated in the finished PBI fiber form thus preventing absorption of chemical agents. The fiber has shown demonstratively low absorption for chemical agents4.

TEST PROGRAM RESULTS AND ANALYSIS

The material tests for the various fabrics have been completed and a ranking of each of the candidates has been put together. Of the various concepts including the current British mark I the Saratoga possesses the best chemical agent protection both new and when laundered. Through the use of the thermal manikin test which measures the insulation properties of a fabric the saratoga and gentex concepts ranked as the best5 See table 1. The test data listed in table 1. is the Copperman test performed by Army Research Institute of Environmental Medicine (ARIEM).

The PBI based Rohm and Haas fabric demonstrated the best flame resistance. Finally the cost ranged from S100 for the disposable mark I ensemble to $350 (Est.) for the Rohm and Haas ensemble.

SUMMARY

What we have concluded from this development effort so far is, that to reduce the thermal stress and subsequently improve the comfort of an individual is best achieved simply by eliminating the multiple layers of protective gear and improving the moisture and air permeability of the garment. The difficult aspect is to combine the un compatible components into a composite fabric that works as one integrated system.
Secondly if we are to replace the current disposable system with a stand alone garment it must be durable enough and launderable enough to make it a cost effective alternative.
The durability, Launderability, and wear life issues will be evaluated in our upcoming wear trials at the conclusion of the test program it will be determined which system will best support our operational forces needs.

Table 1. USAF Chemical Protective Uniforms
Thermal Manikin Test Data

	clo1.	im2.	im/clo
Battle Dress Overgarment Army (baseline system)	1.97	0.34	0.17
1. Winfield Inc. Monopak Saratoga, Aramid shell fabric	1.45	0.34	0.23
2. Gentex Inc. Intimate blend fabric, AC fiber, Aramid fiber	1.42	0.31	0.22
3. Hylla Saratoga flight suit	1.61	0.31	0.19
4. UK Undercoverall, flight suit	1.82	0.32	0.18
5. Rohm & Haas Inc. Reactive and Absorptive Resin in PBI fiber	1.61	0.34	0.21

Note:
1. Insulation value of a fabric, 1 clo= 0.18 Deg. C m2 Hr/ Kcal
2. Moisture Evaporative impedance, Range 0-1.0, 0=Totally impermeable, 1.0 Totally permeable.

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THE FRENCH FLIGHT PROTECTIVE EQUIPMENTS

PRESENT AND FUTURE

by Maj. Gen. (Ret.) Pierre G. RICAUD

Member of the French Defense Science Board

Missions from chemically contaminated areas demand that aircrews are protected against CW agents on ground-inside base buildings and during transfer to aircrafts. Protection must be afforded in flight if the cockpit is ontaminated.

This protection must be compatible with other flight equipments or these equipments must integrate the chemical protection of the body and the head.

BODY PROTECTION

The French aircrew protective clothing is an air- and perspiration-pervious suit, made of two layers, stopping toxic liquids and vapors (Fig.1). The outer layer is made (1) of KERMEL(2)-viscose fire-proof fibers, with an oil - and water repellency finishing giving a high head-elimination capability: so toxic drops or aerosols will not adhere, they slide or stream off and break into dropplets.

The toxic vapors, which could penetrate the outer layer, are absorbed by activated charcoal of the inner layer. This coconut-shells charcoal (3), with a very large specific surface and an excellent distribution/pore sizes, impregnates polyurethane foams with fine open cells. These filter foams (4) are bounded to a cotton fabric.

Chemical suits for AF ground people and overalls for Army are made on this principle (5).

For aircrews, this suit (see Fig.2,3 and 4) is made up with a ring collar for an air-tight junction with the head protective devices.

(1) DMC Co

(2) RHONE-POULENC Co aramid

(3) PICA Co

(4) TRAMICO Co

(5) BOYE or UGECOMA, approved suppliers

This suit is complemented with special two pieces gloves and charcoal impregnated socks from a material similar to the suit one.

No basic changes are expected in a near future for these suits, but improvements in the fibers-inclusion of a glass filament core - in the impregnated foam to allow decontamination...

HEAD PROTECTION

PRESENT STATE : Fighter pilots

Presently the face, eyes and respiratory tract protection is ensure by an "Over the helmet hood" (6) attached to the standard French Air Force helmet. (Fig. 3 and 4).

The French Hood Blower Systems consists of :

- a hood/mask shroud
- the FAF standard aircrew helmet and oronasal mask
- a ventilation air manifold
- an aircrew breathing filter
- a portable air filter/blower unit
- air hoses

The hood/mask shroud covers entirely the oronasal mask and the helme to which it is fixed by snaps. Made of fire-proof neoprene rubber, it includes a flexible polycarbonate visor and extends to the flight suit ring collar. A tear-away wire embedded in the fabric around the face lets release the visor and pull off the oronasal mask to avoid drowning and suffocation.

On arrival on board, the pilot disconnects the manifold from the portable filter/blower unit used on ground, and connects it to the aircraft filter/blower for ventilation air and to oxygen system for brea (an automatic valve closes the ventilation hose during transfer, and a chest breathing filter after the oxygen regulator prevents contaminati of inhaled oxygen).

Each blower provides 100 l/min air, filtered through two standard canisters, which maintains overpressure inside the head/neck cavity for protection and cooling.

A rechargeable battery powers the portable unit, while the aircra one operates on aircraft 28 volts DC power.

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(6) ULMER Co

This equipment is adopted by the FAF for its fighter pilots.

FUTURE DEVELOPMENTS

Fighter pilots

Two French firms (7) develop jointly an integral head equipment providing all the functions of a standard fighter pilot helmet, plus his chemical protection.

This equipment includes : (Fig.5)

- an integral pressurized helmet
- a ventilation/air filtering system
- a respiratory/oxygen filtering system
- an oxygen connector
- the present NBC suit and its accessories

The integral pressurized helmet (Fig.6) is made up of :

- a Kevlar/carbon shell
- an inner shell
- an anti-glare and - laser visor retractable between the two shell
- an external NBC visor with integral rubber seal
- a flexible collar, sealed to the helmet, covering the shoulders, and overlapped by the NBC suit
- a port connecting the helmet to the air filtration unit
- an internal duct, directing air along the visor for demisting

The external NBC visor can be set in 3 positions:

open : turned over the helmet
stand-by : in front position, but not sealed
NBC : sealed in front position

The oxygen mask is clamped inside the helmet which has a connection to oxygen circuit from the pneumatic filtration unit.

The pneumatic filtration unit (Fig.7) includes in the same casing:

- an air ventilation/filtration unit which supplies slightly pressurized air for leak protection, visor demisting cooling and breathing on ground
- a filter unit connected in the oxygen circuit, between the regulator and the oxygen mask, with a compensator for filter and hose pressure drop. So the pilot can use the pressure demand oxygen supply in usual condition.

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(7) BRONZAVIA AIR EQUIPMENT and GUENEAU-GENO

The casing contains one rechargeable battery for each unit, for use on ground. On board, a casing rack is connected to the 28 volts DC supply.

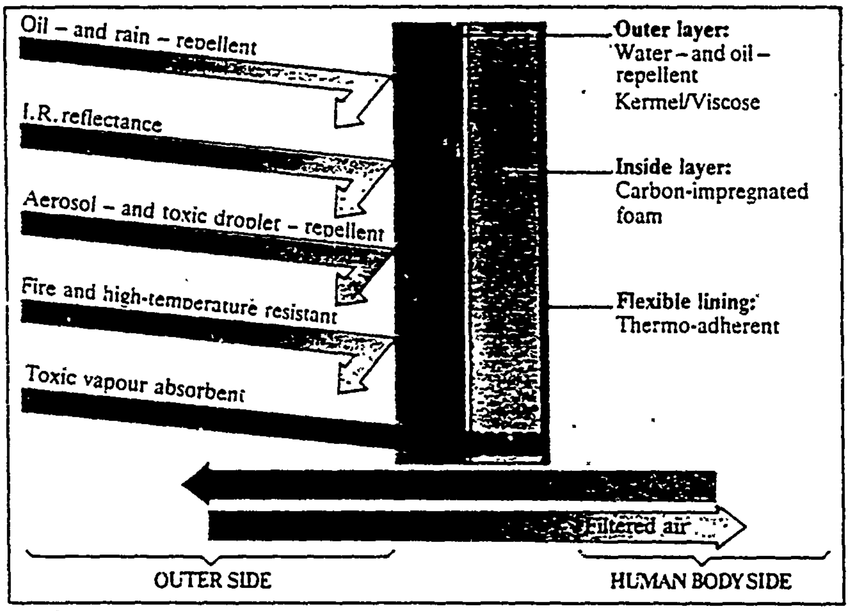
In case of ejection, the pneumatic filtration unit is automatically disconnected and both the helmet inside and the oxygen mask are supplied with oxygen from an emergency cylinder (Fig.8)

Helicopters and aircraft crews, other than fighter pilots

Equipments similar to the present or future fighter pilots ones are developped for other aircraft or helicopter crews. These are simpler, without oxygen mask, circuit and filtration (Fig.9).

For this purpose an "under the helmet" mask is also studied(Fig.10): the polymer-made face piece with anti-laser visors wears an exhaust valve, a vocal membrane and a drinking device. A hose connects it to a filtering canister, itself connected to a ventilation/filtration unit powered by batteries. This unit, directly power supplied on board, might be disconnected on ground.

To sum up, French Air Force procures now a good level of protection to its fighter pilots. Simpler equipments are under development for the other crews, including helicopter crews.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Kermel/Viscose
Inside layer:
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Thermo-adherent
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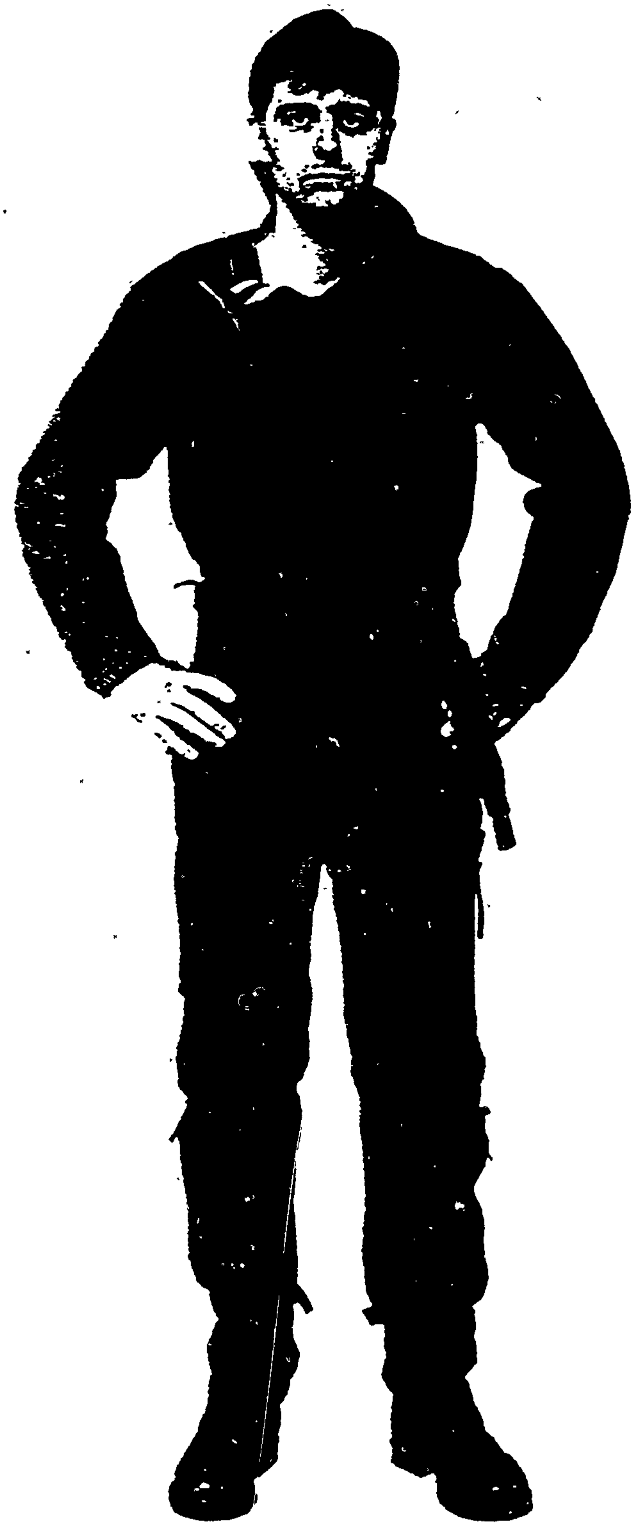
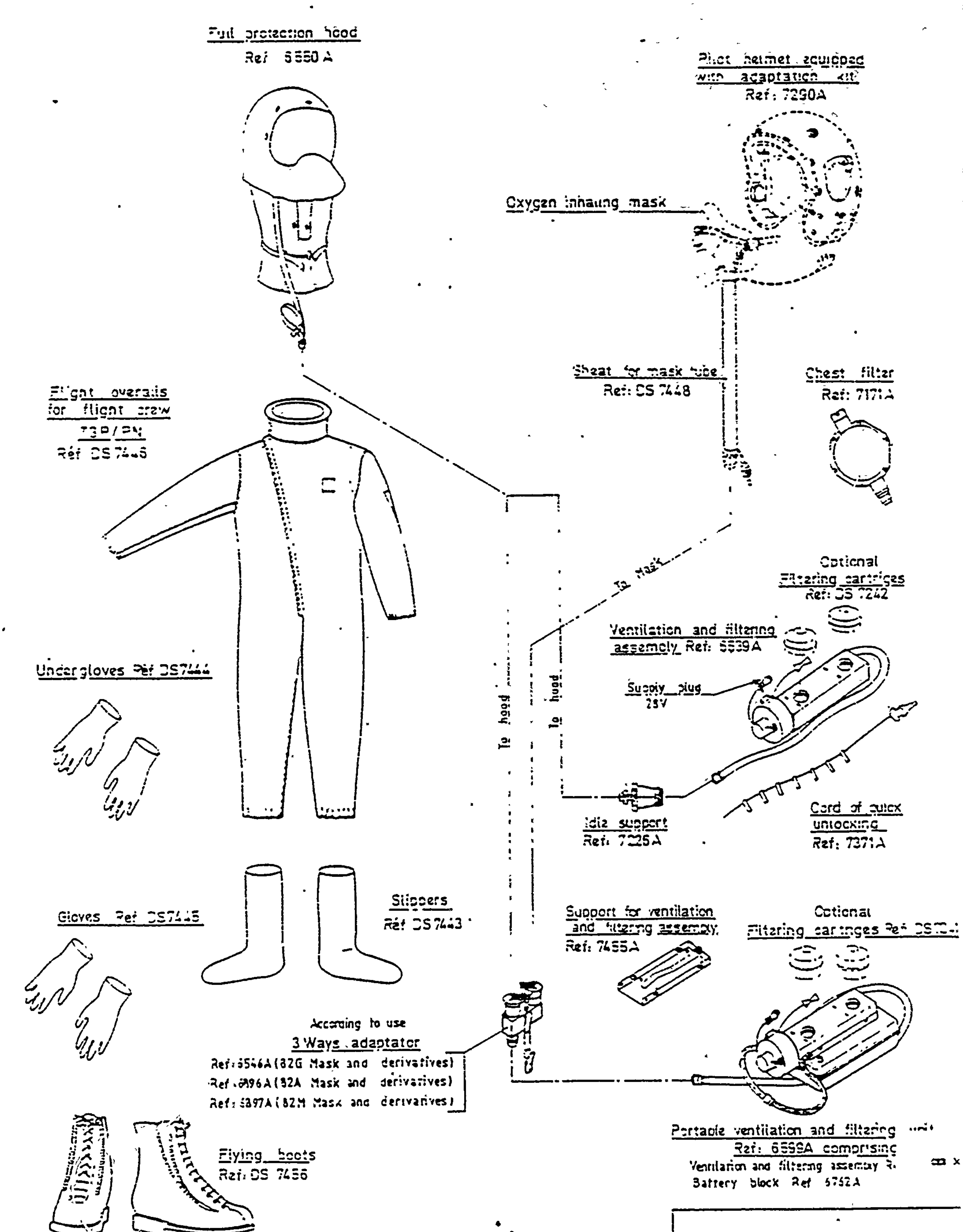
OUTER SIDE
HUMAN BODY SIDE

PROTECTING CLOTHING

Type T3P



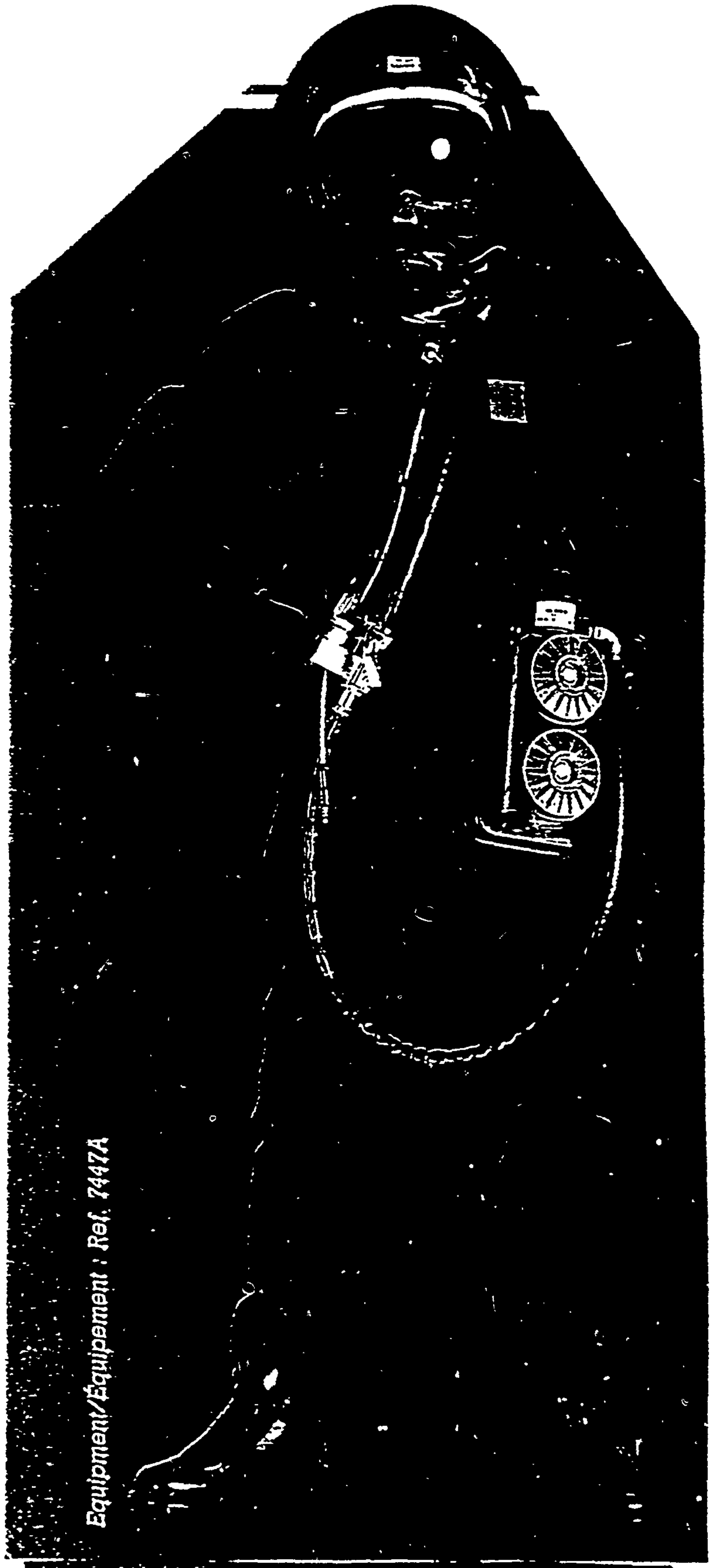
PAUL BOYÉ



ULMER AERONAUTIQUE

NBC PROTECTION UNIT FOR FLIGHT CREW

Fig. 3



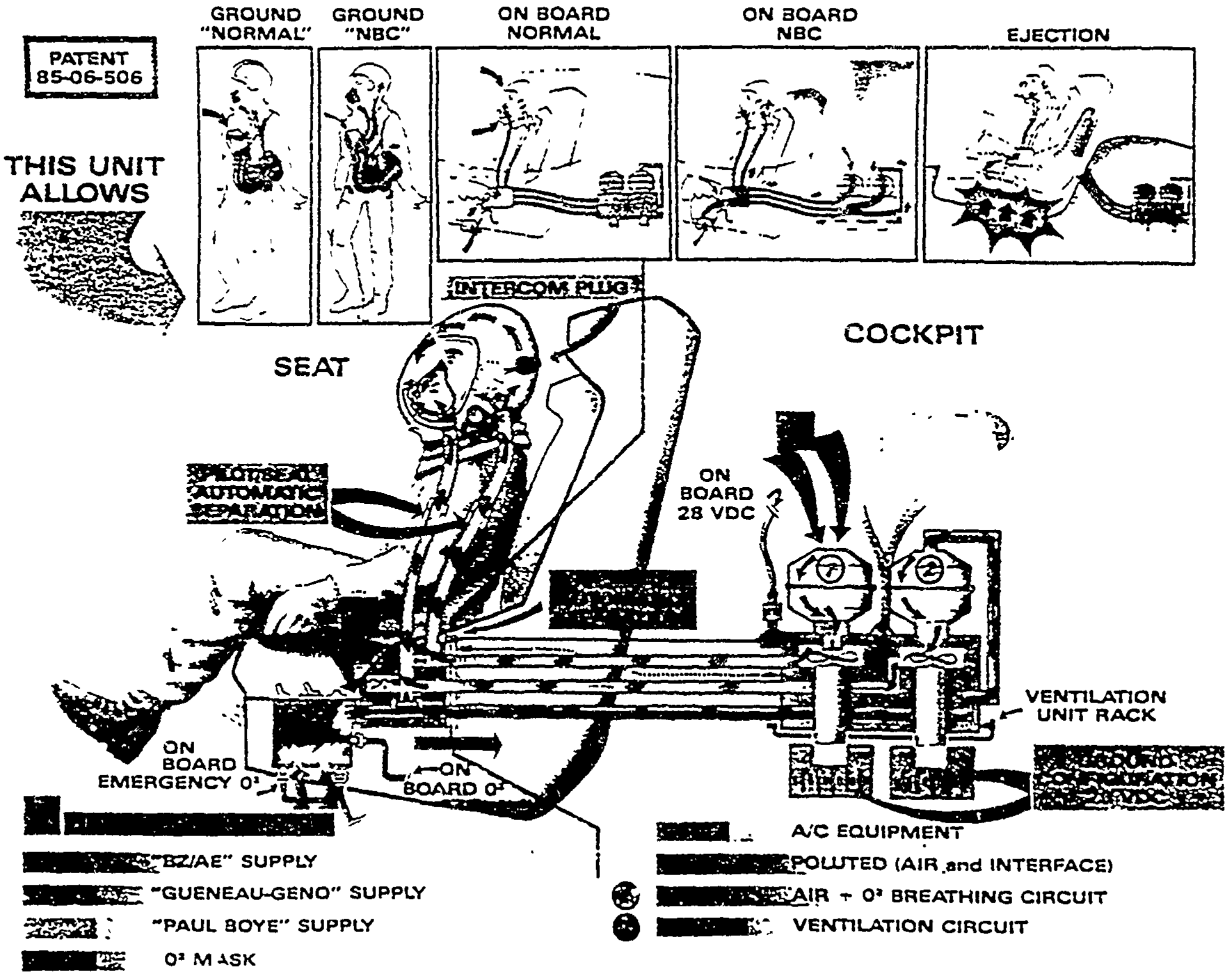
ULMER

UGECO INTERNATIONAL

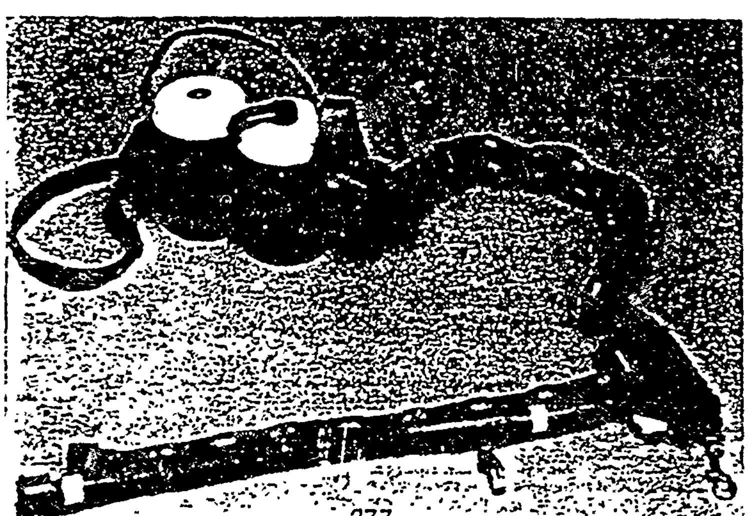
BRONZAVIA-AIR EQUIPEMENT
PAUL BOYÉ

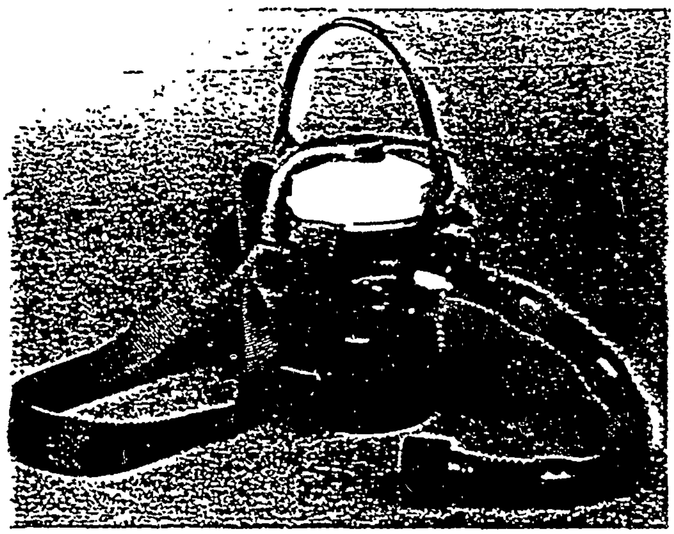
BRONZAVIA-AIR EQUIPEMENT
PAUL BOYÉ
GUENEAU-GENO

OPERATING SCHEME



PNEUMATIC FILTRATION UNIT





BRONZAVIA - AIR EQUIPEMENT
PAUL BOYÉ
GUENEAU - GENO

HELICOPTER CREW EQUIPMENT

CHEMICAL WARFARE CHALLENGE TO NATO AIR BASES

Dr. Clyde R. Replogle
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Special Projects Office

The Air Sub-Panel (ASP) of the NATO Army Armaments Group (NAAG) NBC Defense Panel (Panel VII) formed an Ad Hoc Group of Experts (GOE) to define the liquid and vapor challenge levels on air bases resulting from chemical attacks. This definition is essential in order to establish criteria for design concepts in chemical warfare (CW) defense. Such concepts allow CW defensive equipment, facilities, doctrine, and procedures to be designed so as to minimize degradation, restriction, and cost, but at the same time, maximize protection. This representation examines the potential liquid and vapor chemical challenge to air bases based on Warsaw Pact capabilities. Included are detailed discussions on CW agent selection, weapon systems, tactics, air base vulnerability, target categorization, and weapon allocations.

TITLE OF PRESENTATION: SALTY DEMO

PRESENTATION CLASSIFICATION: NATO SECRET (This narrative unclassified)

Col Edwin L. Stanford

SALTY DEMO was one of the largest demonstrations of air base survivability (ABS) ever conducted. Its purpose was to realistically demonstrate integrated ABS elements, to measure sortie generation capability after an attack, and to provide decision-making information for acceptance or continued development of improved ABS capabilities.

Air bases must be able to survive repeated attacks and continue to generate sorties. ABS initiatives enhance our ability to disrupt and destroy attacking forces, protect personnel, quickly return the injured to duty, limit damage, and ensure the survival of command and control capabilities.

To provide realism and credibility, SALTY DEMO was held at a USAF main operating base in central Europe during April and May 1985. SALTY DEMO used in-place ABS capabilities, newly fielded systems, and development items. Therefore, this documentation was unique and not a tactical evaluation of the unit's combat readiness.

Ten functional area working groups assisted in the planning, scheduling, executing, and reporting of SALTY DEMO. Over 1,000 people collected data and assessed the results in support of this effort.

The volumes of the NATO-releasable version, SALTY DEMO final report, are as follows:

VOLUME #	TITLE
I	Executive Summary
II (Part 1)	Purpose and Description
III (Part 2)	Combined Functional Analyses
IV	Aircraft Operations
V	Aircraft Generation
VI	Active Defense
VII	Base Recovery After Attack
VIII	Command, Control, and Communications
IX	Medical
X	Nuclear, Biological, and Chemical Defense
XI	Camouflage, Concealment, and Deception

Eighty copies of the NATO-releasable version of the Air Base Survivability Demonstration Final Report, YQ-DR-86-2, 19 Aug 1986, were sent to various NATO agencies when the report was originally published. Since then, the entire report has been sent to the Defense Technology Informaion Center (DTIC) for further distribution. Additional copies should be obtained, in whole or in part, through the following agency (contact the appropriate technical library for assistance):

Defense Technical Information Center (DTIC)
Cameron Staion
Alexandria VA 22314

SALTY CHASE 87

Lt Col Allan M. Dickson
Armstrong Aerospace Medical Research Laboratory
Special Projects Office

Exercise SALTY CHASE 87 was conducted jointly by the Aeronautical Systems Division (ASD) Life Support System Program Office, the Armstrong Medical Research Laboratory (AAMRL) and the 50th Tactical Fighter Wing (50 TFW) at Hahn AB, Germany during 2-4 February 1987. In response to directions from the Commander in Chief, U.S. Air Force - Europe (USAFE), the exercise was planned as a Command Post Exercise (CPX) for the 50 TFW Wing Operations Center (WOC) Battle Staff. The exercise demonstrated the Chemical Hazard Assessment System (CHAS) and validated the AAMRL Chemical Warfare (CW) data bases in an operational environment.

The exercise Control Staff consisted of representatives from AAMRL augumented by personnel from the 50 TFW. The Control Staff simulated friendly operations external to the WOC such as higher headquarters, units assigned to Hahn AB, and aircraft generation, launch and recovery. The Control Staff also simulated enemy attacks, chemical contamination, casualties, air base damage and other activities through use of the AAMRL CW data base and CHAS simulations of ongoing operations.

Use of Air Base Contamination Management Information

Robert J. Reyes, Ph.D., Deputy Director
Lt. Steven D. Miller, Program Manager
Lt. Zoe M. Hale, Program Manager
Chemical Defense Advanced Development Program Office
Human Systems Division

Air base mission effectiveness is directly measured by the number of sorties generated. A combined conventional/chemical attack on an air base decreases the sortie generation effectiveness. The purpose of this paper is to descibe the chemical contamination information needed, as well as how it can be used, to regain effective sortie generation. The air base Survival Recovery Center (SRC) monitors contamination levels and conventional damage and directs corresponding actions before and after air base attacks. The threat of or actual chemical attack will require the SRC commander to obtain warning, dewarning, monitoring and all-clear information. Each of these functions provides critical information for contamination avoidance, decontamination and Mission Oriented Protective Posture (MOPP) reduction decisions. We will define the above information needs, describe the use of the information for contamination management decision making, and descibe how use of effective decision making will promote higher sortie generation rates. The results of our analysis will show that sortie generation can be improved by minimizing chemical agent contamination and reducing MOPP levels. We conclude that an air base detection system composed of an area detection system and a network of point detectors will provide the timely and accurate chemical agent information needed to make effective contamination management decision, which will minimize the degrading effect of combined conventional/chemical attacks.

Operational Analysis - A More Detailed View

Dr. John T. Bartlett
CDE Porton Down, UK

A fundamental element of any Operational Analysis (OA) Study of operations on an airbase in a chemical environment is a realistic appreciation of the probable nature of chemical attacks on the base.

Work in the UK has concentrated upon defining realistic scenarios for attacks on RAF bases by enemy forces, taking account of the types of agents and the delivery systems available to possible attackers.

The initial results of these studies will be descibed and an indication will be given of the possible distribution and duration of the chemical hazard on a typical airbase filling what are believed to be credible attacks.

USAF/NATO Conference "Maintenance of Air Base Operations in a Chemical Warfare Environment."

Fire Fighters Chemical Warfare Ensemble

Briefing Paper Material
Briefer: Mr Wade H. Grimm

Research into the effects of conventional weapons on an air base show that without passive defensive measures, the air base fire fighter faces numerous, simultaneous fire fighting tasks. The crash rescue mission of the air base fire fighter directly affects the generation of sorties more than any of his other missions. Of the many resources required to effectively operate in a wartime environment, his protective clothing is vital to accomplish his taskings.

Existing fire proximity clothing has an unsatisfactory use-life (4-6 months), is heavy (28 pounds), and has a very limited capability in a chemical warfare environment. Fire fighters currently don the ground crew ensemble in a CW environment which provides them no protection from the flames or heat of a fire. As a result, they must remain inside their vehicles during fire fighting operations. This severely hampers their effectiveness. AFESC has developed an ensemble which provides CW and proximity protection for fire fighters in a fire fighting/rescue environment. The ensemble consists of the following:

- a 5-year wear life proximity suit
- a CW protection undergarment
- a CW/communications fire fighting helmet
- a 2-hour self-contained breathing apparatus

CHEMICAL DEFENSE COMMUNICATIONS

BY

MARK R. STEPHENSON

CHARLES W. NIXON

INTRODUCTION

Several factors in Chemical Defense environments may substantially reduce the sustained effective task performance required for mission accomplishment. Primary factors are the chemical agents and antidotes themselves. However, the personal equipment essential for protection may also interfere with the capability to accomplish mission objectives. Voice communications effectiveness is one important performance capability that has been degraded to varying degrees by some CD masks and hoods. Nevertheless, effective voice communications are vital to successful task performance by many AF personnel in CD environments. Personnel who accomplish activities such as aircraft maintenance, aircraft quick turn around, air traffic control, security enforcement and emergency medical care must be able to communicate effectively while wearing CD individual protective equipment (IPE). The voice communications features of IPE systems must be investigated to identify those providing satisfactory voice communications, as well as those with deficiencies that require improvements to achieve acceptable communications. In concert with these requirements the Armstrong Aerospace Medical Research Laboratory (AAMRL) has been conducting a program with the following objectives:

(1) To identify deficiencies and weaknesses in audio communications performance of current CD protective equipment.

(2) To develop guidelines and specifications for CD systems that will ensure acceptable voice communications.

(3) To develop techniques for effective interfacing of communications gear in individual protective equipment to standard voice communication links.

(4) To develop and evaluate new voice communication concepts and systems with CD applications.

Fulfillment of these objectives will provide a great measure of assurance that effective task performance in CD environments will not be subverted by inadequate voice communications. This paper discusses the results of analyses of the voice communication performance of selected current CD protective equipment and the status of the present and planned R&D efforts to provide enhanced voice communications in CD environments.

I. EVALUATION OF VOICE COMMUNICATIONS WHILE WEARING THE MCU-2/P CD PROTECTIVE MASK

The MCU-2/P is an all purpose chemical defense protective mask designed for use by ground personnel in a wide range of operational environments. Voice communications capability is provided by two voicemitters. A small diameter voicemitter, located on the right side of the mask, is designed for use with a standard commercial telephone handset.. A larger diameter voicemitter, located in the front of the mask, is designed primarily for use in face-to-face communications, but may also be used with communication equipment such as the walkie-talkie radios.

Approach

Four different communication configurations were employed to evaluate the voice communications capabilities of the MCU-2/P mask:

(1) Talker and listener wore the MCU-2/P mask and hood in face-to-face situations.

(2) Talker and listener wore the MCU-2/P mask and hood and communicated using the standard commercial telephone handset interfaced with the small voicemitter.

(3) Talker and listener wore the MCU-2/P mask and hood and communicated with the security police hand held walkie-talkie interfaced with the large voicemitter.

(4) Talker and listener wore the MCU-2/P mask and hood with the H-133 ground communication headset over the hood; the talker spoke into the "tear-drop" microphone noise shield held tightly against the large voicemitter.

Investigation of the voice communications in each of these configurations was accomplished using the facilities of the AAMRL Voice Communication Research and Evaluation System (VOCRES). Ten experienced volunteer subjects were fully trained to participate in voice communications effectiveness studies. All subjects were otologically normal and had hearing threshold levels of 15 dB or less at standard audiometric test frequencies from 500 Hz to 6000 Hz.[1] The test of choice for evaluating the performance of military communication equipment is the Modified Rhyme Test (MRT).[2] The MRT consists of multiple lists of 50 one-syllable words. The test is administered by having a talker speak a test word embedded in the standard carrier phrase, "Number..., you will mark __________, please." Listeners then select from a set of six words displayed before them, that word which was believed to have been spoken by the talker. The results for a given word list are reported in terms of the average percent correct for the number of listeners participating in that phase of the study. The scores are adjusted for correct answers obtained by guessing, and the final percent correct score is referred to as the intelligibility level for that condition. A more detailed description of the equipment and procedures used to conduct these intelligibility studies has been previously published in AAMRL TR-85-050.[3]

Evaluations in this investigation were accomplished in two different noise environments: (1) a low level, broad band noise (in this case, 77 dB SPL re 20 uPa), and (2) the far-field noise environment of an F-15A tactical aircraft with both engines at 80% RPM as measured at a distance of 73 meters from the aircraft. The spectrum of the F-15 environment was accurately reproduced in the AAMRL Biological Acoustics Branch high intensity sound facility, using measurement data provided by the AAMRL Biodynamics Effects Branch.[4] The overall sound pressure levels of 95 dB, 105 dB and 115 dB were representative of the operational noise levels in a flight-line environment.

Performance Criteria

On the basis of past data, experiences, and reports from field personnel a set of criterion measures of the VOCRES laboratory data has been adopted as a predictor of the expected performance in operational situations. Using the VOCRES laboratory and methodology described, systems and components that perform at an intelligibility level of about 70% or less are usually unacceptable for operational applications. Those with intelligibility ranging from 70% to 80% are characterized as providing marginally acceptable communications, their success in the field being dependent upon the specific conditions under which they are employed. Communication systems exhibiting intelligibility performance of 80% or above are fully acceptable under most operational conditions. The MCU-2/P mask performance was evaluated relative to these criteria.

Results of Communication Evaluations of the Standard MCU-2/P Mask and Hood

Overall, satisfactory voice communications with the MCU-2/P mask and hood were obtained only in the low level noise conditions of this investigation. Speech intelligibility progressively decreased as the levels of the noise conditions were increased until communication was totally unsatisfactory at the highest level noise conditions. Appendix 1 summarizes the communications performance of the MCU-2/P.

Face-to-Face Communications

Percent correct intelligibility scores are presented as a function of communication configuration, separation distance and noise condition in Figure 1. Speech communications were satisfactory in the baseline condition with intelligibility scores of 80% and better except for the marginal performance at the separation distance of ten feet in the 105 dB level of noise. The MCU-2/P configurations with and without the hood showed good communications for the 77 dB noise condition, however, intelligibility is unsatisfactory for the 95 dB and 105 dB conditions at both separation distances.

Subjects wore an Air Force standard earmuff sound protector during the 105 dB noise conditions in compliance with allowable noise exposure standards cited in AFR 161-35, Hazardous Noise Exposure. The duration of the test session exceeded the allowable exposure time for that level for unprotected ears, therefore subjects were provided earmuff hearing protectors. As a consequence, the measured speech communication performance was reduced by the additional sound isolation provided by the earmuff device in combination with the mask and hood. Personnel are prohibited from wearing the mask and hood without hearing protection in the operational situation for the durations and highest level of noise used in this communication configuration. The use of the earmuffs in the 105 dB noise condition is a realistic representation of an operation situation.

In virtually all measurements the speech intelligibility was less at the ten than at the three feet separation distance. Differences ranged from about 2% to 9% and were greater for 95 dB and 105 dB than for the 77 dB noise condition. Intelligibility scores were only slightly less for the mask measurements with the hood than without the hood, indicating that it had very little effect on performance.

Intelligibility for all face-to-face conditions was adversely affected by the noise exposures. The greatest reductions occurred for the mask conditions which showed a drop from the baseline data of about 40% for the 95 dB and 50% for the 105 dB noise conditions. The mask conditions in the higher level noises exhibited speech intelligibility scores of about 40% and less for all conditions.

Commercial Telephone Handset

Data for voice communication performance with the telephone handset and the "walkie-talkie" handset in the noise environs is summarized in Figure 2. Telephone handset voice communications were quite good with the mask and hood in the 77 dB noise condition. The intelligibility dropped from 94% at 77 dB to 69% correct at the 95 dB level of noise. The standard deviation values of ±10% were more than double those measured in the 77 dB noise, indicating a substantially increased variability in communication performance.

"Walkie-Talkie" Handset

Speech intelligibility data for the "walkie-talkie" handset in noise is also shown in Figure 2. Voice communications were satisfactory in the 77 dB noise but dropped to 64% in the 95 dB noise condition. As with the telephone handset, the standard deviations for the 95 dB noise were about double the values measured in the 77 dB condition. Subjects wearing the MCU-2/P mask and hood displayed somewhat better intelligibility when interfacing with the commercial telephone handset than with the "walkie-talkie handset." However, both instruments provided satisfactory communications in the 77 dB noise and unsatisfactory communications in the 95 dB noise.

H-133 Ground Communication Headset

The communications capability of the MCU-2/P mask and hood using the standard Air Force H-133 ground communications headset with the AIC-25 intercommunication system in four different noise environments is summarized in Figure 3. Performance is shown as mean percent correct intelligibility and standard deviation scores. Satisfactory voice communications were measured in the two lower level noise conditions of 77 dB and 95 dB. Communications were marginal to unsatisfactory in the 105 dB noise and clearly unsatisfactory in the 115 dB noise. At noise levels above 95 dB, the percent correct intelligibility decreased about 15% for each 10 dB increase in the level of the noise environment. Standard deviation values were reasonably small except for the 105 dB condition where they were double the value of those for the other noise conditions.

The H-133 ground communications headset-microphone unit is designed to provide acceptable voice communications in noise levels of up to about 135 dB. The unit typically provides satisfactory communications in the field in all except some test cell type environments. This study shows that the MCU-2/P mask and hood interface with the H-133 unit results in a significant reduction in voice communications capability for the H-133 unit at the level of 115 dB. The communications capability with these systems in the field is expected to be seriously deficient at noise levels above 115 dB that are experienced in typical aircraft ground maintenance activities.

Summary

The above data clearly demonstrate the existence of significant deficiencies and weaknesses in audio communications for persons wearing the MCU-2/P mask and hood. Voice communications were unsatisfactory in all except the lowest noise levels for face-to-face communications and with the hand telephone, walkie-talkie, and H-133 ground communications headset equipment. The specific reasons for the lack of adequate voice communications differ, depending on the communications configuration and the interface with the mask and hood. These reasons include such factors as the size and fit of the equipment, the quality of the voicemitters and the mating of the handsets with the mask. However, all of these result in the overriding factor which is the masking effect of the ambient noise conditions on the speech signal.

II. DEVELOPMENT OF EFFECTIVE COMMUNICATIONS WITH CD PROTECTIVE ENSEMBLES

Present IPE voice communications capabilities are provided by voicemitters or by wearing existing headsets over CD mask and hood ensembles. The preceding section demonstrated that these provide unsatisfactory and/or impractical communications capabilities in many operational environments. This section discusses efforts designed (1) to develop a highly portable communication system for IPE, and (2) to develop a microphone for use with the MCU-2/P mask. A combination of these two concepts should result in a communication system which is lightweight and highly portable, offers a high level of speech intelligibility and is compatible with CD personal protection requirements.

Development of an Infrared Communication Headset

Pilot efforts conducted by this laboratory demonstrated the feasibility of an infrared line-of-sight voice communications system. The present effort will develop a wireless, personal, infrared, line-of-sight voice communication system that is compatible with CD personal protective ensembles. Successful development and application of this technology will satisfy the need for an effective voice communication system for use in a wide variety of operational situations.

The development of the "bread-board" operational model will proceed in four phases. Phase one will be the design phase. Present plans call for the design of a battery powered headset that will interface with standard AF headgear and provide speech intelligibility equivalent to that provided by a hardwired system, i.e., the H-133 headset, under identical conditions. Following design approval, two preliminary bread-board units will be constructed and delivered for laboratory evaluation. The results of these evaluations will form the bases for phase three, the design of an advanced bread-board model. Within three months of approval of the design for the advanced bread-board model, 10 units will be constructed and delivered for testing. The design of these units shall be sufficiently developed to permit initiation of preliminary field trials.

Successful development of the T-R headset will provide the nucleus of a versatile voice communication system for use by many AF personnel in CD environments. However, improved voice communication effectiveness will also require adaptation of the CD mask to include a microphone.

Development of a CD Mask Microphone

Two CD mask microphone concepts have recently been developed and evaluated. The first concept involved adaptation of the MCU-2/P front voice-mitter to include an internally mounted M-101 microphone. The second concept involved replacement of the front voice-mitter with an M-169 microphone internally mounted on a chemically impermeable disc. Hereafter, these two modifications will be referred to as the mic-mitter and mask-mic, respectively.

Evaluation of the mask microphone was conducted using the VOCRES research facility at AAMRL. The equipment and procedures followed are similar to those previously described above for the evaluation of the MCU-2/P mask. As before, speech communication effectiveness was measured with the Modified Rhyme Test.

Voice communications were evaluated in the following configurations:

(1) Talkers wore the MCU-2/P mask and hood with the mic-mitter modification. Listeners wore the MCU-2/P mask and hood with the H-133 headset over the mask and hood.

(2) Talkers wore the MCU-2/P mask and hood with the mask-mic modification. Listeners wore the MCU-2/P mask and hood with the H-133 headset over the mask and hood.

Figure 4 compares the intelligibility scores for the mic-mitter with those for the mic-mask. Also shown are the intelligibility scores for the MCU-2/P mask and hood in which the H-133 headset-microphone was worn with the "tear-drop" noise shield directly over the large voicemitter. There continues to be a predictable relationship between speech intelligibility (as measured by percent of words heard correctly) and the noise environment of the talkers and listeners. At the lowest noise levels, all microphone/headset combinations performed satisfactorily. As the noise levels increased and the percent intelligibility decreased, the differences between the microphone systems become more apparent. Of the two developmental microphone systems, the mask-mic consistently demonstrated better intelligibility than the mic-mitter.

The data represented in Figure 4 for the 115 dB noise condition are of particular interest. This noise level is representative of many flight-line and engine maintenance noise environments. The mic-mitter performance in this condition is better than that of the H-133 worn over the MCU-2/P. The mask-mic provides greater intelligibility than the other units, however all fall below the criteria for satisfactory voice communications in operational situations.

The mask-mic modification is the system of choice for use with the MCU-2/P mask, however at the higher noise levels voice communications are still marginal to unsatisfactory. Figure 5 presents the intelligibility of an H-133 headset worn without a CD mask (talker and listener wearing H-133 headsets) and worn over the MCU-2/P mask with the mask-mic. The former represents the best intelligibility that can presently be obtained with a standard ground communication headset in high level ambient noise. This data illustrates that adding the mask-mic to the MCU-2/P provides improved voice communication but does not equal the performance of the H-133 in the highest level of noise.

Future Efforts

Integration of the mask-mic with the infrared headset is currently being planned for FYs 1988-1990. In addition, plans are also underway to incorporate recent advancements in active noise reduction technology into the CD voice communication headset. Active noise reduction (ANR) is a method of reducing acoustic noise levels of low frequency sounds by generating an out of phase acoustic signal to cancel the undesired acoustic noise. This process significantly increases the headset's hearing protection, thereby improving intelligibility. These characteristics have been verified during laboratory trials of the ANR headset at AAMRL. The amount of improved sound attenuation and speech intelligibility provided by the ANR are shown in Figures 6 and 7.

Interfacing ANR technology with the infrared system and the further integration of this system with a CD mask microphone will result in an effective voice communication system for use with CD protective equipment. This design would meet the need for portability and the need for effective voice communications in high ambient noise. Current plans call for final laboratory testing by the end of FY 1990 and availability of advanced models for field testing shortly thereafter.

SUMMARY

The Armstrong Aerospace Medical Research Laboratory, Biological Acoustics Branch, has completed a series of experiments examining the voice communications effectiveness of the MCU-2/P mask. Results demonstrated generally unacceptable voice communications in noise in face-to-face situations as well as with existing headsets, telephones and walkie-talkies. Persons in CD environments need voice communication systems designed for use with CD personal protective ensembles. An effective system must provide good sound attenuation, speech communication in noise and be lightweight and portable.

An infrared line-of-sight voice communication system is being developed to satisfy these needs. A CD mask microphone is being developed to further improve speech intelligibility characteristics. Finally, recent advances in active noise reduction technology have been successfully applied to voice communications headsets. Plans to interface ANR technology with an integrated IR headset/mask-microphone communication system should be complete by the end of FY 1990.

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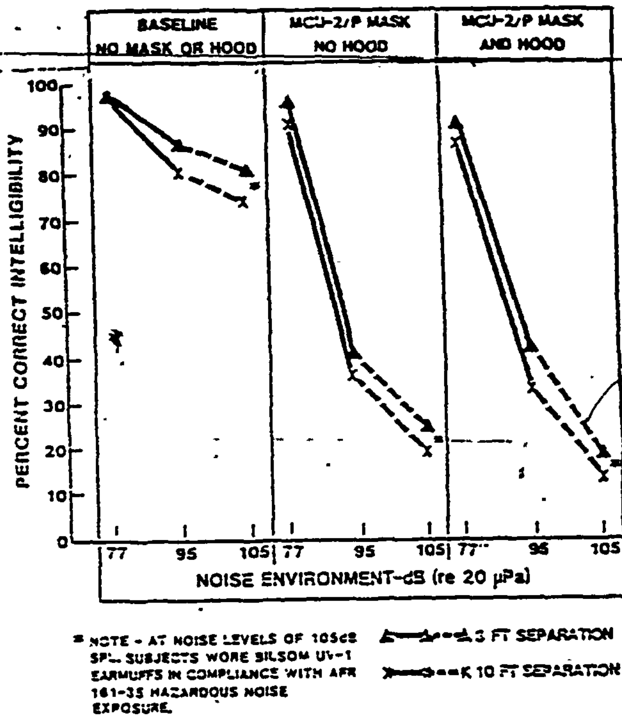
1. American National Standards Institute. American National Standard Specifications for Audiometers S3.6-1969.

2. House, A. S., Williams, C. E., Hecker, M. H. L. and Kryter, K. D. Articulation Testing Methods: Consonantal Differentiation with a Closed Response Set. J. Acoust. Soc. Amer., 1965, 37, 158-166.

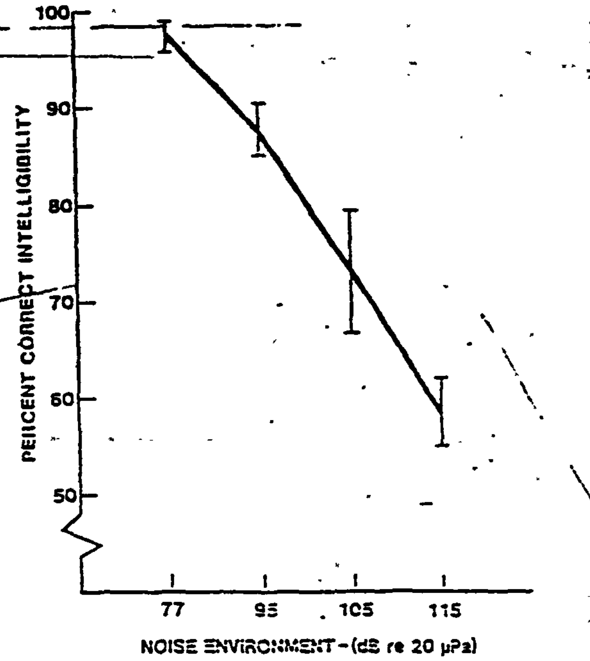
3. Nixon, C. W. and Decker, W. H. "Voice Communications Effectiveness of the All-Purchase MCU-2/P Chemical Defense Protective Mask," AAMRL TR-85-050, August 1985.

4. USAF Bioenvironmental Noise Data Handbook, F-15A Aircraft, Near and Far-Field Noise, Volume 63, AMRL TR-85-50, November 1975.



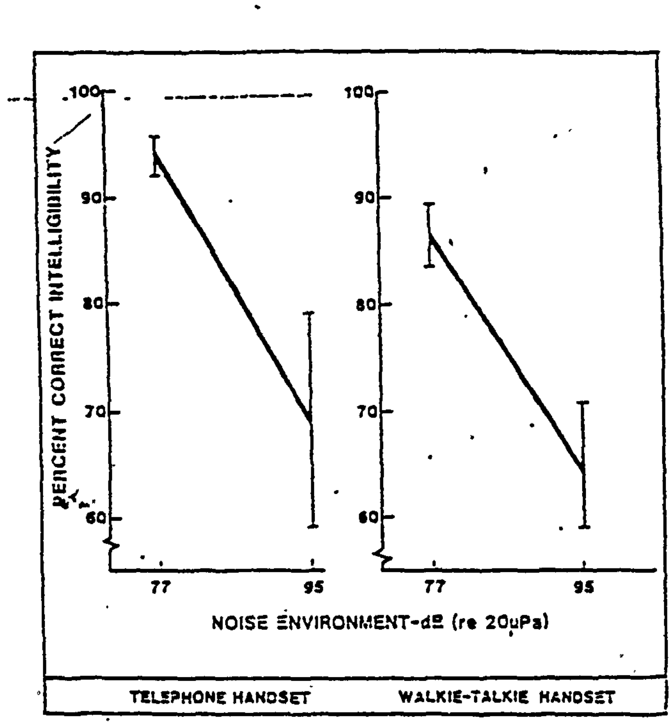
FACE-TO-FACE COMMUNICATIONS. PERCENT CORRECT [illegible] DISTANCE AND NOISE CONDITION

FIGURE 1



SPEECH INTELLIGIBILITY (± 1 STANDARD DEVIATION) OF THE MCU-2/P [illegible] ENVIRONMENTS

FIGURE 3



VOICE COMMUNICATION PERFORMANCE (± 1 STANDARD DEVIATION) OF THE MCU-2/P MASK AND HOOD WITH THE TELEPHONE AND "WALKIE-TALKIE" HANDSETS IN THE NOISE ENVIRONMENTS

FIGURE 2

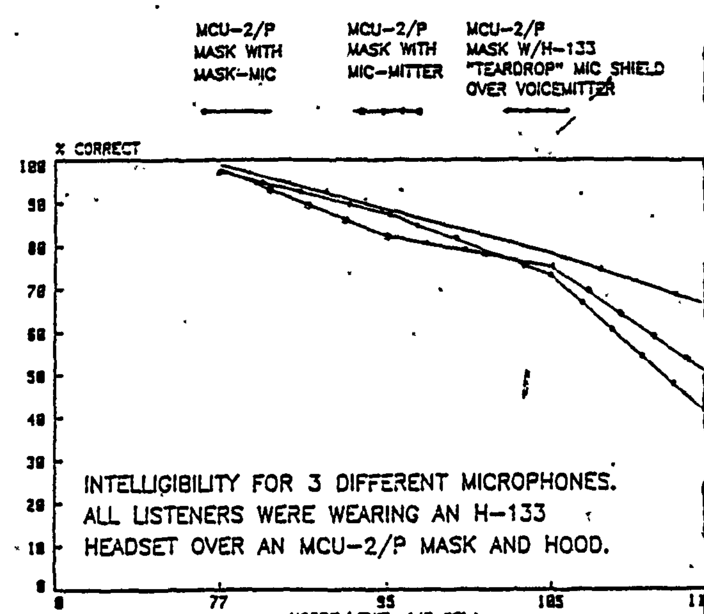


Fig. 4

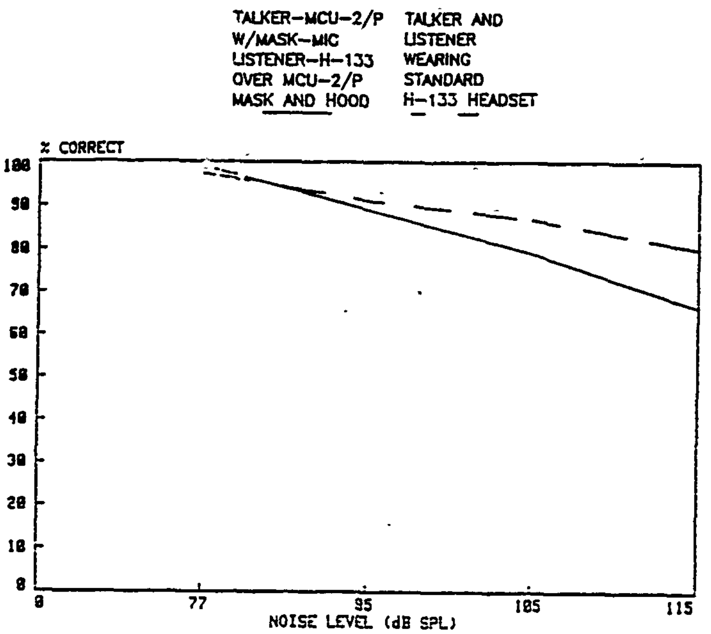


Fig. 5

ANR INTELLIGIBILITY IN C–130 NOISE

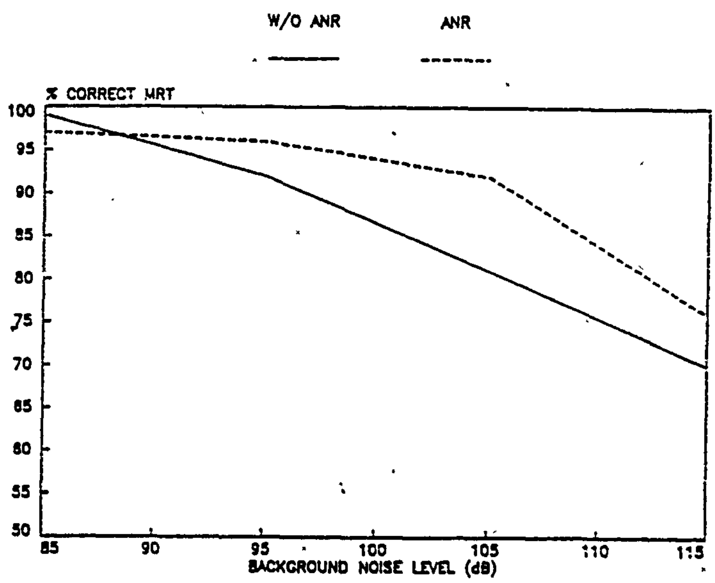


FIGURE 7

ANR ATTENUATION PERFORMANCE

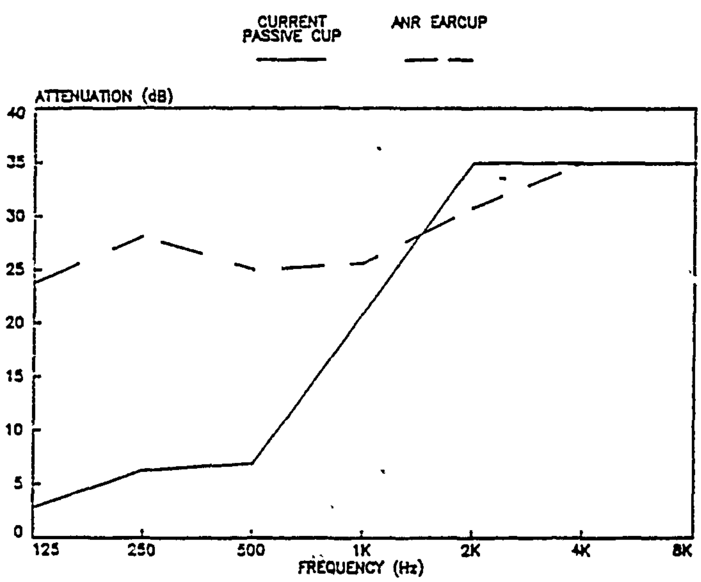


FIGURE 6

APPENDIX 1

VOICE COMMUNICATION PERFORMANCE OF MCU-2/P IN VARIOUS COMMUNICATION MODES IN MODERATE AND HIGH LEVEL NOISE.

95 dB SPL

Communication Condition	Performance* Satisfactory	Marginal	Unsatisfactory
Face-to-Face (Baseline)	#		
MCU-2/P			#
MCU-2/P with Hood			#
MCU-2/P with Telephone			#
MCU-2/P with Walkie Talkie			#
MCU-2/P with H-133	#		

105 dB SPL

Communication Condition	Satisfactory	Marginal	Unsatisfactory
Face-to-Face (Baseline)	# (3 ft)	# (10 ft)	
MCU-2/P			#
MCU-2/P with Hood			#
MCU-2/P with H-133		#	# (at 115 dB)

*Scores for satisfactory performance (>80% intelligibility) represent communications circumstances in which most messages are heard correctly the first time. Marginal performance (70-80% intelligibility) represents circumstances in which communications are unclear and must be repeated. These messages may or may not be understood even with repeated transmissions, thereby increasing the risk that persons may not be able to perform their tasks. Unsatisfactory performance (<70% intelligibility) represents conditions in which the information content of messages is not sufficient for understanding or satisfactory task completion.

Norwegian Model for Eye/Respiratory Protection of F-16 Pilots

Dr. Bjorn A. Johnsen
Per J, Karlsen
Norwegian Defence Research Establishment
Norway

The Norwegian development of an eye/respiratory protection for F-16 pilots was originally based on an over-helmet hood. This model seems to interfere with the function of the pitot ports at the ejection seat in the plane and initiated our work to develop a new model avoiding a bulky hood over the helmet. The Norwegian model is instead based on the idea of enclosing the space in front of the helmet by use of the existing pilot equipment. The vesir and the oxygen mask are then connected to a specially designed rubber front. The protection is based on a continuous flow of clean air introduced close to the eyes inside the enclosed area. The stream of air prevents penetration of contaminants.

The equipment has a protection factor higher than 10,000 when the air stream is varied between 10 and 60 liters per minute. In this experiment a concentration of 100 ppm isoamyl acetate was applied. The protection properties of the Norwegian model is therefore satisfactory. In addition, pilot training in laboratory and in flight are carried out with satsifactory results.

AGENDA

Sunday, 30 August

1600-2100 Pre-Conference Registration

1830-1930 Reception - Cash Bar

Monday, 31 August

0700 Registration

0830 Administrative Announcements -- Mr. Frederick E. Anderson, ASD/AE

0840 Introduction -- Col Raymond A. Shulstad, ASD/AE

0845 Welcome Address -- Lt. Gen William E. Thurman, Cdr ASD (AFSC)

0915 Opening of Conference -- Col Raymond A. Shulstad

0930 Refreshment Break

GENERAL SESSION

Chairman: Mr. Fredrik E. Anderson, ASD/AE

1000 USAF Chemical Warfare Defense Program (G) -- Lt Col Lawrence Hagenauer, Office of the Assistant Secretary of the Air Force (Acquisition)

1030 US Army CW/CBD Overview (G) -- Dr. Billy Richardson, US Army, PEO for Chemical and Nuclear

1100 US Navy Overview of CBR Defense Survivability Issues (G) -- Dr. Gloria Patton, NAVSEA System Command

1200 Lunch -- Keynote Address, Gen Charles L. Donnelly, Jr. USAF (Ret)

1400 US Air Force Air Base Operability (ABO) Overview (ABS) -- Col Edwin L. Stanford, AD/YQ (AFSC)

1430 Design and Acquisition of Nuclear, Biological and Chemical (NBC) Contamination - Survivable Systems (ABS) -- Maj Gerard M. Miknis, OSD

1500 NBC Contamination Survivability (ABS) -- Dr. William S. Magee, Jr, CRDEC

1530 Operations Analysis-An Overview (ABS) -- Dr. John T. Bartlett, United Kingdom

1600 Chemical Warfare Proliferation (G) -- Mr. Gary B. Crocker, State Department

1900 Informal Reception -- Cash Bar

Tuesday, 1 September

0800 Conference Desk Opens

0820	DUAL SESSION BEGINS

SESSION I

Administrative Announcements

Contamination Control
Chairman: Dr. William S. Magee, Jr, CRDEC

0830 Base Recovery After Attack Training (BRAAT) (ABS) -- Lt. Col. Horst G. Haeusser, AFESC/RDC

0900 Commanders' Guide For Operating In a Chemical Environment (G) -- Maj Craig A Reichow, AD/YQO

0930 Medical Aspects of Chemical Warfare: Operational Reality (G) -- Col Craig H. Llewellyn, USUHS

1000 Refreshment Break

1030 The Nuclear, Biological and Chemical Operations Interservice Working Party -- The US Services NBC Operational Access to NATO (G) -- Maj Robert J. Kainz, USANCA

1100 Avionics Decontamination Program (CC) -- Capt Candace J. Tomlinson, ASD/AESD

1130 US Army Decontamination Program Overview (CC) -- Dr. James A Baker, CRDEC

1200 Lunch

1300 A Portable Contamination Monitoring Unit (CC) -- Maj Gen (Ret) Pierre G. Ricaud, France

1330 NBC Sanator -- New Developments (CC) -- Mr. Steven R. Harlacker, CRDEC

1430 Optional Tours of Colonial Williamsburg with Dinner at Selected Inns --

SESSION II

Administrative Announcements

Collective Protection
Chairman: Lt Col James Seawell, ASD/AESD

0830 Chemical Warfare/Chemical-Biological Defense Information Analysis Center -- Mr. Stephen E. Lawhorne, CRDEC

0900 Chemical Defense Data Base (G) -- Mr. Fred C. Meyer, Jr., AFWAC/MLSA

0930 Collective Protection for Air Bases (CP) -- Maj Gen (Ret) Pierre G. Ricaud, France

1000 Refreshment Break

1030 Survivable Collective Protection System Program (CP) -- Mr. Curtis L. Moser, ASD/AESD

1100 Transportable Collective Protection System (CP) -- 1Lt Regina M. Connor, ASD/AESD

1130 Chemically Hardened Shelter System (CP) -- Mr. Jose A. Miletti, NRDEC

1200 Lunch

1300 Advanced Air Purification Systems (CP) -- Mr. Charles M. Lawson, CRDEC

1330 The Personal Protective Equipment - Collective Protection Interface (CP) -- Mr. Robert E. Simpson, USAF School of Aerospace Medicine (KRUG)

1430 Optional Tours of Colonial Williamsburg with Dinner at Selected Inns --

Wednesday, 2 September

0730 Conference Desk Opens

0750 Administrative Announcements

0800 USAFE Chemical Defense Program -- Lt Col William R. MacPherson, Maj George B. Tredway, Capt William R. Saunders, Capt Dale G. Derr, 1Lt Charles E. Morrison, USAFE

0945 Refreshment Break

1000	Dual Sessions Begin

SESSION I

Chemical Detection, Identification and Warning Threat (CDIW)

Chairman: Dr. Clyde E. Replogle, AAMRL/HET

1000 German Chemical Detection Fluorescence Monitor (CDIW) -- Mr. Wolfgang Diehl, Dipl.-Ing Federal Republic of Germany

1030 Use of CAM on Airbases (CDIW) -- Dr. John T. Bartlett, Mr. David A. Blyth, United Kingdom

1100 Remote Detection of Chemical Agents by IR-Lidar (CDIW) -- Mr. Wolfgang Diehl, Dipl- Ing., Federal Republic of Germany

1130 DISC/DIAL Technology for CB Detection (CDIW) -- Mr. Kirkman R. Phelps, CRDEC

1200 Lunch

1300 Area and Remote Detection in an Air Base Environment (CDIW) -- Maj Gen (Ret) Pierre G. Ricaud, France

1330 Fixed Site Detection and Warning System (FSDWS) (CDIW) -- 1Lt Jeffrey C. Stephan, ASD/AESD

1400 Future Use of the Chemical Hazard Assessment System (CHAS) (CDIW) -- Mr. Burnham R. Foley, ASD/AESD

1430 Refreshment Break

1500 Assessment of the Chemical Contamination Density by Means of Liquid Detection Paper (CDIW) -- ir. M. van Zelm, The Netherlands

1530 US Army NBC Reconnaissance Program (CDIW) -- Mr. Joseph D. Wienand, CRDEC

1900 Reception/Conference Banquet -- Cash Bar

Banquet Speaker -- Col Hugh Stringer, Jr., Deputy for Chemical Matters, OSD

SESSION II

Individual Protection (IP)
Chairman: Mr. William Yri, ASD/AE

1000 Representing the Human as a Three-Dimensional Solid for Personal Equipment Design and Evaluation (IP) -- Mrs. Kathleen M. Robinette, AAMRL/HEG

1030 MCU-2/P Chemical Biological Mask Program (IP) -- 1Lt Christopher Erickson, ASD/AESD

1100 Impermeable Chemical Defense Suite (IMP) (IP) -- Mr. Juanita Vertrees, ASD/AESD

1130 Impact of Individual Protective Equipment (IPE) on Performance of Air Base Maintenance Operations (IP) -- Capt Alan Deibel, AFHRL/LRC

1200 Lunch

1300 Tactical Life Support System (IP) -- Lt Col Mark A. Massen, HSD/YAL

1330 Aircrew Eye/Respiratory Protection Program (IP) -- Mr. Robert Tompkins, ASD/AESD

1400 Netherlands Chemical Defence Gear for F16 Pilots (IP) -- Dr. J. Medema, The Netherlands

1430 Refreshment Break

1500 Chemical Protective Clothing Systems for Aircrew Applications (IP) -- Mr. Louis Schwieterman, ASD/AESD

1530 The French Flight Protective Equipments, Present and Future (IP) -- Maj Gen (Ret) Pierre G. Ricaud, France

1900 Reception/Conference Banquet -- Cash Bar

Banquet Speaker -- Col Hugh L. Stringer, Jr., Deputy for Chemical Matters, OSD

Thursday, 3 September

0715 Transportation to Ft. Eustis

0800 Registration and Security Check

0820 Administrative Announcements

CLASSIFIED SECRET SESSION

Airbase Survivability/Operability (ABS)
Chairman: Col Edwin L. Stanford, AD/YQ (AFSC)

0830 Threat Overview (G) -- Mr. Charles Clark, DIA

0900 Chemical Warfare Challenge to NATO Air Bases (G) - Dr. Clyde R. Replogle, AAMRL/HET

0930 Salty Demo (G) - Col Edwin L. Stanford, AD/YQ (AFSC)

1030 Refreshment Break

1045 Salty Chase 87 (G) -- Lt Col Allan M. Dickson, AAMRL/HET

1115 Use of Air Base Contamination Management Information (CC) -- Dr. Robert J. Reyes, HSD/YYAL

1145 Operational Analysis - A More Detailed View (ABS) -- Dr. John T. Bartlett, United Kingdom

1215 Lunch

1330 Fire Fighter's Chemical Warfare (CW) Ensemble (IP) -- Mr. Wade H. Grimm, AFESC/RDFC

1400 Chemical Defense Communications (G) -- Maj Mark R. Stephenson, AAMRL

1430 Norwegian Model for Eye/Respiratory Protection of F-16 Pilots (IP) -- Dr. Bjorn A. Johnsen, Norwegian Defence Research, Establishment, Norway

1500 Refreshment Break

1530 Conclusion -- Mr. Fredrik E. Anderson

Legend:		
	(G)	General
	(ABS)	Airbase Survivability/Operability
	(CDIW)	Chemical Detection, Identification and Warning/Threat
	(CC)	Contamination Control
	(IP)	Individual Protection
	(CP)	Collective Protection

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NATO CONFERENCE

31 AUGUST - 4 SEPTEMBER 1987

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